ENGINEERING

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RT FROM BRUSSELS

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MECHANICS
ACHINING

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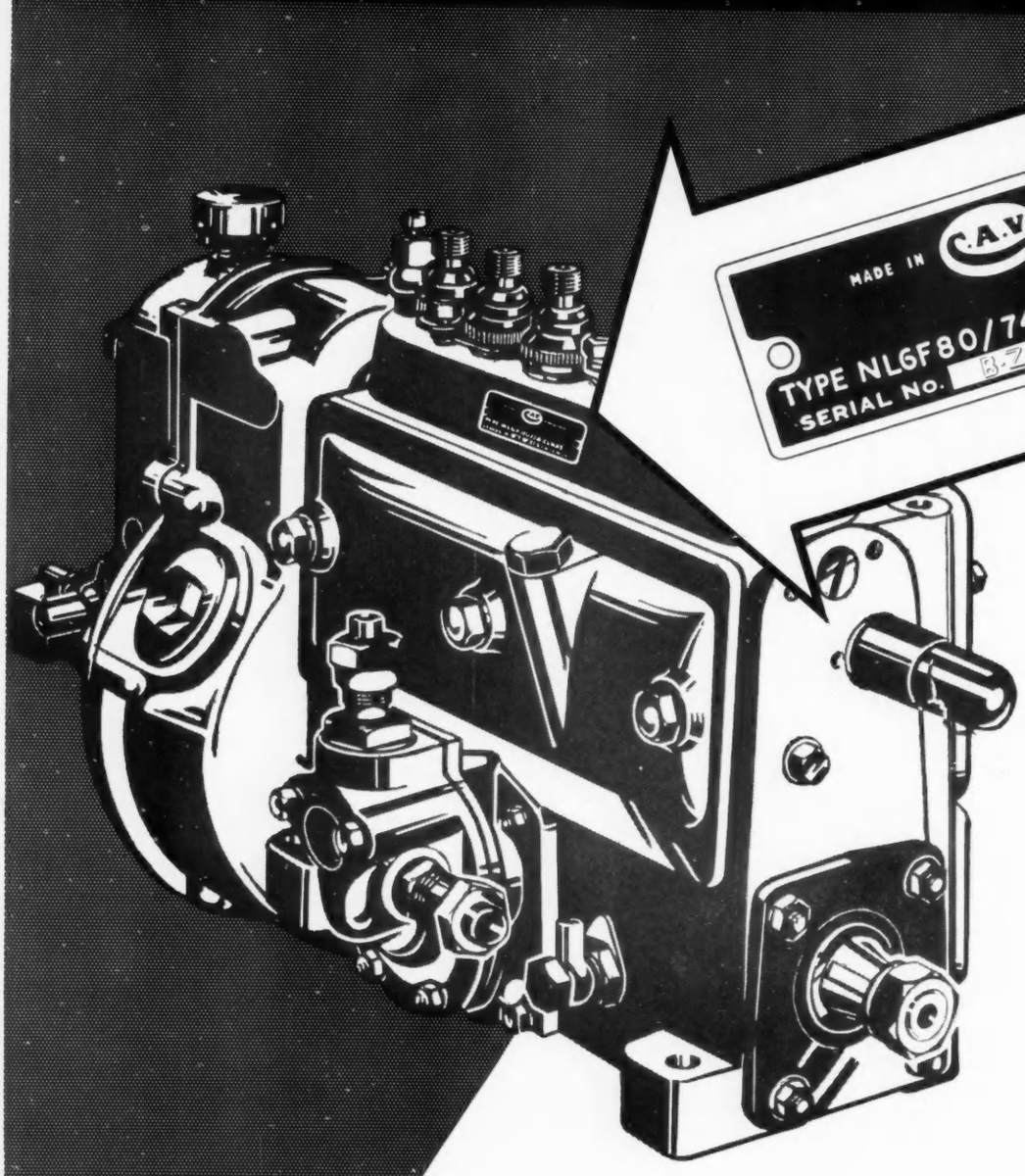

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Trade with Canada

THE political landslide in Canada that returned Mr. Diefenbaker and his Conservative Government to power has also given them an unqualified mandate to carry out their policies. Basic among those policies is that of switching 15 per cent of Canada's imports from the United States to Britain and so reducing dependence on her neighbour. Trade, like momentum, has magnitude and direction; in this case the "mass" is expanding fast and some considerable force will be required to change the direction.

At the end of last year the Canadian trade mission came over here to start the business of switching trade to this country. The mission was the largest ever sent here to buy British goods. It was a purchasing mission but, more than that, it was fifty-seven experienced industrialists seeing what they could get here at prices competitive with those in their own country and in the United States. For almost a month they toured the country, visiting firms and getting to know industry. Now their report is published. It is intended for circulation both over there—to tell their compatriots what they saw and what they thought—and over here so as to make it clear to manufacturers in the United Kingdom what the members of the mission believe can be sold in Canada. It is a straightforward document entitled *Report of the Canadian Trade Mission to Britain, November* 21 *to December* 18, 1957, *made to the Government and People of Canada by the Members of the Mission.* The report will be printed in Canada and when available will be circulated, free of charge, to all who showed interest in the activities of the mission.

At a Press conference in London to launch the report, Sir William Rootes, chairman of the Dollar Exports Council who helped to sponsor the mission while it was here, described it as "interesting and constructive." He could have gone further and said it was readable, for although most official reports contain the facts, few present them in such a free and easy manner. It has also the prime virtue of brevity: 44 typed quarto pages are sufficient for the report and the final "expressions of appreciation," with another 26 pages for the appendices.

The facts of the case are well known. Canada has almost unlimited raw materials (there is about as much oil in the Canadian Arctic as there is in the Sahara, and the latter is reported to be sufficient for Western Europe for the next 100 years) and an expanding economy; from a population of 17 millions to-day, it is expected to be 40 millions by 1984 and 70 millions by the year 2000. Mr. Diefenbaker and his supporters think Canada depends too much on the United States for trade. Shift a proportion from the United States to Britain and the balance of payments position will be improved all round. The mission came here to make contacts and to establish goodwill. The report makes it clear that they were successful and have gone back full of praise for what they saw. Taken overall, quality of workmanship was good; delivery time and the supply of spares need be no worse than from the United States; and cost is emphatically right—after all, the Canadian pays only 2·75 dol for every £1 of goods which, for the most part, are still worth the pre-devaluation 5 dol.

What then are the snags? The report is quite clear on the subject. The 49th parallel is no bulwark against the flow of newspapers, trade and technical journals, magazines and films from the United States. It has been estimated, continues the report, that apart from the commercial content of the radio and television, over 500 million pieces of American advertising go into Canada every year. But the report dismisses any suggestion that would-be exporters should slavishly copy United States fashions and styles. It recommends that Canadian engineers should "consult regularly the excellent and authoritative British trade and technical publications which many members of the mission had the opportunity of studying in Britain."

But gaining trade with Canada needs also salesmanship over there. The Board of Trade and the Dollar Exports Council will be following up Mr. Diefenbaker's victory. The Board's president, Sir David Eccles, is to pay a visit for two days at the end of April—in all he expects to be over there three times in 1958. A strong DEC delegation, headed by Sir William Rootes, begins a coast-to-coast tour in Ottawa the day this issue of ENGINEERING is published. Much of the success of the Canadian mission was due to the excellent coverage it received from the British national and technical Press. Already teams have gone from the instrument makers and the petroleum equipment makers. Both groups came back optimistic of the prospects, and individual members came back with contracts in their pockets. Price, delivery, and confidence both in the product and the service behind the product will generate the force to bring Mr. Diefenbaker's policy to fruition.

Cover Picture. *The sand cores for the lower crankcase of a large internal-combustion engine casting are seen being assembled. The finished aluminium-alloy sand casting weighs about 5 cwt.*

* * *

Plain Words

If you are an engineer, are you one of those who first set foot on the path to your career by wanting to be an engine-driver? Or were you so good at mathematics and physics that a friend of your father said you would make a good engineer? Or perhaps you were so hopeless at everything that your father said "He'll have to go in for engineering." As all three types seem to be able to do well, provided they have the human qualities and character which are essential to success in the profession, it really doesn't matter now how you started. What does matter to-day, I am sure, is whether future engineers of all three types should be given practical training in the shops.

There seems to be a sharp division of opinion between those who hold that some practical training is essential for every engineer, and those who believe that the young engineer of high academic qualifications who will probably go in for research should not waste time on the shop floor. The Conway Committee's report to the Institution of Mechanical Engineers on this subject of practical training, which was reported in last week's issue of ENGINEERING, makes a definite recommendation in favour of such training. The only concession they would allow is for the trainee to specialise towards the end of his training; the future research engineer, for example, would spend little time in the shops and more in the test and research departments.

I have yet to meet someone who would allow the research engineer to dispense entirely with practical training. Maybe there are such people, but they must be in a minority. In any case, I cannot agree with them. Engineering is a practical art; it is the economic application of scientific research, and if the engineers who do the research haven't the faintest idea how the research has to be applied, they will be only partly effective. No one is asking them to become skilled mechanics, but they ought to know what the mechanic does and how he does it. It is lack of practical experience, I think, which has reduced the contribution made by architects of this country. Why don't architects lay a few thousand bricks, mix concrete, and practise the art of building for a short time in their youth? They would be much better architects if they did.

In some shops, I hear, there are difficulties in arranging for apprentice engineers to have practical training. Separate training schools help to get round these difficulties, but we ought to resist this trend. Only in the production shops can the engineer in training gain an understanding of the chief function of his profession. He will have plenty of time after that to wash his hands and scrub his finger nails.

CAPRICORN

Weekly Survey

Indian Dependence

One of the past-presidents of India's Institution of Engineers, Mr. S. B. Joshi, wrote recently that his country's economic stability would not be safe "as long as the science and technique of engineering do not take root in our soil." This was in an article reviewing the progress of consulting engineers and the part they have to play in a country where engineering activity is likely to be tremendous during the next decade. The article was a supplement published by the Institution of Engineers (India) dealing with the growth of professional engineering in India, the development of various sections of the engineering industry and the facilities which exist for education and research.

The membership of the institution has grown from 128 in 1920 to over 18,000 to-day, most of the growth having taken place in the past decade. The two main activities of the institution, apart from those designed to maintain the units and to promote the status of India's engineers, are the provision of educational facilities (last year 2,700 students took the institution's examinations), and the dissemination of technical knowledge. The institution publish their journal in two parts as well as a bulletin, at the end of each month. In addition they run technical, abstract, reprint and other services for members.

The whole of this supplement stresses the important part engineers are playing in the development of Indian industry and agriculture. This is being officially recognised and the status of engineers has been raised considerably since the war. "The builders of the new India" play a leading part in the formulation of industrial policy as well as in its technical execution. The expenditure of Rs. 60 crores (about £5·2 million) on the expansion of engineering colleges and polytechnics, under the second five-year plan, will provide 2,538 additional places in the degree colleges and 4,225 in the diploma institutions. The recommendations of the Scientific Manpower Commission set up in 1947 for the establishment of the four high technical institutions are gradually being implemented, and a number of postgraduate schemes started. The key to this amazing growth probably lies in the following comment of Professor M. Sengupta, principal of the engineering college of Banaras Hindu University: "Engineering education and research are tending to become glamour words both in society and in the field of education."

Uganda Electricity

The tenth annual report of the Uganda Electricity Board shows that the rapid increase in the output of electricity which has been a feature of the last few years, was continued in 1957. From 59·5 million MWh in 1953 the output of the Board's generating stations rose to 94·9 million MWh in 1956 and 148·8 million MWh in 1957. In the latter year, almost 100 per cent of the output was derived from the Owen Falls hydroelectric station where two additional 15 MW generators were brought into commission during the year, bringing the installed capacity to 90 MW. Two further sets are expected to be completed during the current year.

In spite of this increase, the report of the Economist Intelligence Unit submitted last year confirmed that the resources of the Owen Falls dam are likely to be fully utilised by 1965. This will necessitate the start of construction of a second dam not later than 1960. The Board's consulting engineers have accordingly carried out a complete survey of the Victoria Nile from Owen Falls to Lake Albert and a site has been selected at Bujagali, 4½ miles downstream from Owen Falls. Approval has accordingly been given for the preparation of detailed designs for a 180 MW station on this site. Detailed investigations have also been made into possible sites for small hydroelectric stations on the Muzizi River and on the Nile at Karuma Falls; it is hoped to reach decisions early in 1958 on these stations.

The 132 kV double-circuit line of the Kenya Power Company from Tororo to Nairobi was completed during 1957 and arrangements were made for the start of a commercial supply from Uganda to Kenya as from 1 January 1958. Of the increased sales of electricity in Uganda amounting to about 51 million kWh, the Kilembe Mines copper smelter at Jinja accounted for 28·2 million kWh and in addition, the number of consumers rose from 16,798 in 1956 to 19,819 in 1957.

By Any Other Name?

The word "consortium" has become increasingly fashionable of recent years in industry. Outstanding examples in the last decade have been the consortia brought together to supply atomic energy equipment in this country, the civil engineering consortium which was established in connection with the development of the St. Lawrence seaway in Canada and the recent one brought together for the development of harbour installations in Cuba. Two developments in the export field were announced last week. One of them was the formation of the British Consolidated Foundry Plant Manufacturers, consisting of an export group of five concerns, each concentrating on a particular section of foundry machinery. There is said to be little overlapping of interests between members and the consortium is interested not only in selling standard machines but in tendering abroad for complete new mechanised foundries and for extending and modernising old ones. Also last week it was announced that Simon Handling Engineers has joined Rustyfa, the British consortium formed to equip a complete tyre factory at Dniepropetrovsk in the Ukraine.

There are a number of reasons why the consortium should be increasingly popular at the moment. Two of the main ones are that major engineering undertakings often cover a wide range of specialist equipment and substantial financial resources are required by the supplier. These problems are best handled if suppliers come together on some nominally equal basis so far as the customer is concerned and act as partners rather than as contractor and subcontractors. The second reason is the large field of industrial activity which is these days controlled by State corporations and State trading organisations who wish to deal at a top administrative level and yet maintain a fairly close contact with all suppliers in a big industrial project.

Altogether it is a useful and fairly flexible device for adapting a group of concerns on the supply side in this age of specialisation to the needs of a complicated and costly project and to the wishes or even whims of the customer. It breaks down to some extent the pressure which a contractor can often exercise on sub-contractors in the way of quality, price and delivery dates but even this power of the contractor can to-day be taken over by progress chasers.

Company Analysis

The story of a company engaged in the production of locks and latches has been told by an American consultant and published by OEEC as their research project 173. The consultant, Mr. George Arisman, conducted with Dr. Horton Sheldon a series of seminars on company planning and control organised by the European

Productivity Agency. The talks were based on the consultants' own experiences in industry and dealt primarily with the needs of small and medium firms. Mr. Arisman's report is about an actual company, started in a small way with a few machines and men in 1931 by two men who were still in control in 1950, when some 350 people were employed. During the war, only defence equipment was produced and subsequently the company ran into difficulties associated with operating in an inflationary period—concerning the supply of materials of the right kind, the supply of skilled labour and lack of working capital.

This book is not entirely free from either stereotyped thinking or jargon, but it is much more readable than most because it deals with a live subject and an existing company's actual problems. When he outlines the plan evolved to place the business on a sound operating and financial basis, he exhibits a practical turn of mind and down-to-earth qualities rarely found in the writing of experts on management problems.

The introduction of sound organisation, following a detailed analysis of the deficiencies found in the organisational set up, is the key to the whole operation. This enables the establishment of company planning and control through forecast, of a well qualified management team, each with clearly specified functions and responsibilities, of a standard cost system for materials and labour and of expense budgets as a means of controlling expenditure in all branches of the business. The first question, "what should the nature of the business be?" sets the tone in a most searching and stimulating analysis.

Capital Goods Prospect

In a Budget which has been notably free from controversial issues (with two exceptions, one being the decision to establish a standard profits tax of 10 per cent as opposed to the present separate tax on distributed and undistributed profits) the official forecast of capital investment offers one of the few subjects round which argument may develop. In his speech, the Chancellor of the Exchequer said that he expected "to stabilise expenditure in the public sector this year at the same level as last year. Private investment expenditure, so far as can be judged from sample inquiries, also seems likely to stay at about its present level which is in fact an all-time record." Mr. Amory's main preoccupation in fact was lest exports should lag slightly and that stocks should build up too quickly thereby putting a strain on imports.

The only stimuli which he has been prepared to offer to the capital goods industries (and in this respect there is a marked contrast with that section of the engineering industry which makes consumer durable goods and is likely to benefit from the reductions in purchase tax) are, first, a modest increase in the initial allowances by one-quarter so that they become 25 per cent for plant and machinery and 12½ per cent for industrial building. There is to be no change in the 40 per cent special rate for mining equipment. The other stimulus is the instructions issued to the Capital Issues Committee and the recommendation to the banks that expansion of industrial output in areas of severe unemployment (meaning Scotland, Northern Ireland and South Wales) is not to be retarded by lack of capital or acute stringency in obtaining bank accommodation. Such areas are also to benefit from Government assistance under Section 4 of the Distribution of Industry Act and the promise of a Bill to amend that Act so that it can be applied over a wider geographical area.

All these assumptions are based on the forecast that private capital investment will stay high in a period of comparatively high interest rates. Many will think that this is an optimistic interpretation of what may happen. It is quite possible that there may be a serious reduction in the demand for capital by private enterprise even if interest rates fall and that special stimuli will be needed to increase investment towards the end of this year. If that should be so it might need another Budget to bring it about.

Capital in Power

A White Paper published on Budget Day set out the proposed capital investment in the coal, gas and electricity industries. As would be expected, in principle they follow the line of the Government's decision last September to contain the investment of public corporations at their then current level—a policy confirmed in the Budget.

The National Coal Board's approved expenditure for 1958 is £100 million compared with £103 million in 1957 and £96 million in 1956. Of the total, provisionally £83 million has been allocated to colliery development, £5 million to coke ovens and £12 million to various activities including opencast work, central workshops and stores. The Electricity Council and its Area Boards in England and Wales are allowed £239 million for 1958-59 compared with £235 million of the estimated outlay in 1957-58 and £206 million in 1956. Capital outlay on main transmission and distribution is almost unchanged from last year but, on the generation side, conventional stations got £90 million compared with £100 million last year and nuclear stations £37 million compared with £21 million. These figures cover England and Wales. Work on new power stations previously planned for the next 24 months will be spread over 26 months and the completion of a nuclear power programme in last year's White Paper will be postponed one year. A higher proportion of the total new generating capacity required during the period covered by that programme will be in the form of coal-fired stations at lower capital cost. In other words, the rate of changeover from conventional to nuclear stations has been slowed down. In Scotland, total capital outlay will go up from £36 million to £43·5 million.

The Gas Council and Area Boards are scheduled to reduce their capital outlay in 1957-58 from £57 million to £53½ million. Further progress has been made in the integration of gas supplies and with plant to receive and process liquid and gaseous supplies from oil refineries.

Trade Returns

This country's trade gap in March was again small although it was larger than in February. Indeed it was the lowest figure recorded for the month of March since 1949. The adverse balance was only £26·6 million. Imports increased more than exports but they were still well below last year's level and in the first quarter of this year imports have been 12 per cent less in value than in the same period of 1957. In other words, this country continues to benefit substantially from the current low level of world commodity prices.

On the export side, trade with the United States was a record last month and there was even a seasonal increase in shipments to Canada. This country continues to benefit from the very encouraging level of car exports to the United States market. It remains to be seen how far this represents a switch by United States customers from large to smaller cars in a time of recession and how far it represents a wilful stimulus of the United States domestic market for small cars by the big United States automobile manufacturers to see if it is worth their while to invest large quantities of plant and equipment to make such models themselves.

With the trade gap at the low level achieved in the last two months, it is almost certain that this country is running a favourable balance on its visible trade account. Exports remain buoyant for the time being despite the American recession and imports are benefiting from lower world prices.

Letters to the Editor

SUPPORTING RESEARCH ASSOCIATIONS

SIR, Your report (11 April, p. 464) on statements by Mr. R. E. Prentice, M.P., in the House of Commons on the application of science to industry includes some facts about the actual and potential membership of a Government-sponsored research association which has been in existence for more than ten years. As I read the report, Mr. Prentice deplored the fact that the research association had only succeeded in attracting 520 members out of a potential 10,000.

Industrial firms are not charitable institutions. They exist to make a profit for the shareholders, and in doing this they also provide a livelihood for their workers. If their managements are looking after the shareholders' interests, as they should, they will balance the probable direct and indirect benefits of joining a research association against the membership fee before deciding whether to join.

If the council of the research association have wisely limited its field of interest to one in which the research and development staff can hope to become more expert than the staffs of potential member firms, it is likely that the research association will prosper if properly led. If, on the other hand, the field of interest chosen is so wide that the research association cannot hope to cover it properly, then there will be difficulty in attracting members.

Perhaps the most remarkable figure in Mr. Prentice's facts is the 10,000, not the 520.

Yours faithfully,
S. B. BAILEY.

56 Blacketts Wood Drive,
Chorley Wood,
Rickmansworth,
Hertfordshire.
16 April, 1958.

MATHEMATICAL MANUSCRIPTS

SIR, Stimulated by Dr. J. F. Alcock's letter in your issue of 21 March (p. 356), I should like to make another suggestion for reducing labour when preparing mathematical copy for printing or for reproduction by other means.

The author of a paper has to write out his mathematics at least once. If, when preparing his first draft, he writes all "displayed" expressions and equations—the larger the better—as a separate schedule, linked with the text by numbering, this manuscript can be reproduced photographically to meet a number of requirements without errors of transcription.

The extra time the author spends in preparing this one copy with careful attention to layout and legibility will generally be repaid. (Suggestions for writing Latin and Greek letters recognisably, and much other valuable information, are given in *The Printing of Mathematics* by T. W. Chaundy, P. R. Barrett and Charles Batey, Oxford University Press, 1954.) The author will not have to do this job again if he re-drafts the text, nor will cramped manuscript insertion in several carbon copies be necessary. If the paper is to be Rotaprinted, the schedule can be cut up for insertion in numbered spaces left in the typescript text. If it is to be set up in type, "copy" will already be available in the form most helpful to editor and compositor.

Symbols embedded in the lines of text will still have to be inserted by the author (unless the typist can be coaxed into doing this as she comes to them—for which a ball-pen will serve) but this is a minor operation; it may be minimised by "displaying" as much as possible rather than embedding.

The most ingeniously conceived scheme for rationalisation may come to grief if it runs counter to an established habit—especially if the one who has to change a habit is not the one

Continuing Letters to the Editor

who will reap the benefit. Here, moreover, there is the difficulty that many technical authors have not consciously noticed such typographical conventions as the use of Roman letters for operators and italics for variables. There is no reason why they should, and the system outlined above is designed to make only the minimum demand on authors—legibility. The additional burden on the reader of the typescript is not very great—illustrations are usually separate from the text already.

Such a wide range of photo-copying devices is now available that this extra process presents little difficulty. Even a free-lance author might find that a small copier soon pays for itself in terms of his own time and typing costs.

Yours truly,
G. E. DENYER.

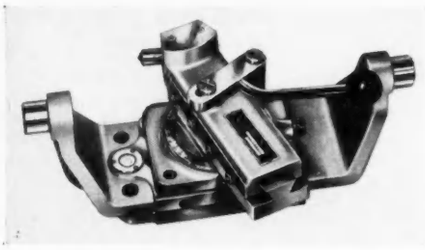
4 Crane Court,
Fleet Street,
London, E.C.4.
14 April, 1958.

Plant and Equipment

GRINDING WHEEL DRESSING

Newly added to the range of grinding wheel dressing equipment made by Engineering Diamonds Limited, 26 Warwick Row, Coventry, is the angle and relief dressing fixture for cylindrical grinding machines shown in the accompanying illustration. The fixture has a precision dovetail slide with two diamond stations, so that either side of a wheel can be dressed, and is lever operated, with a stroke of 2 in. An integral protractor enables the diamond tool to be set at any angle. The front and rear edges of the rectangular base of the fixture are ground square with the slide axis when the protractor is set to zero, and they can be used for alignment purposes. The height of the diamond axis is 2⅛ in, and the fixture can be mounted directly on the machine table by means of an auxiliary base.

When it is desired to apply the unit between the machine centres it is fitted to a base, as shown in the illustration. This base has a spirit level for horizontal setting, and holes are provided to take ½ in diameter support bars reaching down to the machine table surface.



The Endia wheel dressing fixture can be used between centres, or the base can be omitted and the fixture bolted where required.

Automobile Engineering

LOTUS 15

New Sports Racing Model for 1.5 *or* 2.2 *litre Engine*

The world-wide success of the Lotus XI with engines of 750 cc (winner of the Performance Index at Le Mans) to 1,500 cc has induced no complacency in the Lotus organisation. Mr. Colin Chapman has just produced the first of the new Lotus 15's designed to take Climax twin camshaft engines of 1,500 cc or 2,200 cc. Although outwardly resembling the Lotus XI in shape, the car has a lower frontal area obtained by mounting the engine on its side; transmission is through a five-speed gearbox in unit with the differential and it has independent rear suspension. Incorporating the lessons of last year's racing and record breaking, the 15 will be the mainstay of the Lotus attack in this year's sports car races, and has been entered for Le Mans with 1·5 and 2·2 litre Climax engines.

The body complies with Appendix C of the International Sporting Code. A boldly curved windscreen blends into a high tail leaving only a small open space through which the heads of the driver and passenger protrude. Behind the driver is a head rest, inside which the spare wheel stands vertically. To complete careful streamlining, the underside is completely enclosed with no interruptions except for the engine, sump and outlet from the radiator which is fully ducted. The undershield and tunnel over the propeller shaft and gearbox are of light alloy, riveted to the tubular steel chassis frame, and form part of the stressed structure. The frame, which is wider and deeper than that of the XI, is of square and round section steel tubes of 1 in (25 mm) and ¾ in (19 mm) diameter, 18 and 20 gauge thickness. The engine lies at 28° to the horizontal and is carried on a three-point mounting. The crankshaft is at 7½° to the car centre line to bring the propeller shaft back to the centre line at the front of the gearbox.

Normal power unit is the Coventry Climax FPF 4 cylinder (81·2 by 7.11 mm), 1,475 cc engine, giving 150 b.h.p. (153 CV) at 7,200 r.p.m. It has overhead valves at included angle of 66° operated by two gear-driven camshafts, and the crankshaft runs in five indium plated copper-lead bearings. Cylinder block and crankcase are of light alloy. It has two twin-choke S.U. carburettors specially designed for it. Lubrication is by dry sump with an oil tank in the tail of the car and the pipe delivering oil to the tank is finned to act as oil cooler; there is an oil filter behind the radiator. Ignition is by Lucas coil and distributor. The twin plate clutch of 7¼ in diameter (18·4 cm) is hydraulically operated. Engine cooling is by cross-flow radiator with a tiny cylindrical tank functioning as filler, header tank and swirl tank; water is fed into it at a tangent and the vortex created separates out the air.

The five-speed gearbox and differential unit has been improved as a result of last year's racing experience on F2 single seaters. It has its own dry sump lubrication system with pressure and scavenge pumps and a small separate oil tank in the tail. Oil is fed under pressure to the crown wheel and pinion and passes by gravity along the hollow selector shaft to the gears; all gearbox bearings are balls or rollers. All five pairs of gears are in constant mesh. One set revolves freely on a sleeve on the input shaft and the gear to transmit the drive is locked to the shaft by a sliding dog. The five mating gears are locked to the output shaft which is integral with the spiral bevel pinion. The differential is a ZF limited-slip unit.

The gear shift is a positive stop type as on a motor cycle but very unusual in a car, the lever returning to the neutral position after each change. The first gear is engaged by pulling the lever back; neutral and the upper four ratios are obtained by repeatedly pushing the lever forward. Downward changes are made by pulling the lever backwards. Reverse is obtained by pulling a separate knob on the bulkhead between the seats.

Brakes are Girling discs of 9½ in diameter (25·2 cm) with quick change pads, those at the rear being mounted alongside the differential. The transmission unit with brakes and drive shaft weighs only 85 lb (38·6 kg). In all of the four upper gears, ratios can be changed by simply drawing the gears off the shafts. First gear is only used for starting and its ratio does not change, so the driver does not have to learn a new starting technique when the transmission ratios have been varied.

Rear suspension is the Chapman strut type as on the F2 but the coil spring-damper strut does not lie at such an acute angle. At the top it is attached to the chassis frame and at the bottom it rests in the light-alloy hub casting. The wheel is also located by the drive shaft (two universal joints and no splines) and by a cranked tubular radius arm trailing from the rubber bush on the chassis. The front suspension is of the type now standard on all Lotus cars, with coil springs and wishbones. Rack and pinion steering has a sharply cranked steering column passing under the engine.

For long distance racing where tyres have to be changed, centre lock wire wheels are used, but for shorter events the special Lotus magnesium bolt-on disc wheels are available giving a saving of 30 lb (13·6 kg) unsprung weight per set of four. Front and rear sections of the body panelling lift off and the centre section can be removed by undoing six bolts.

The car looks similar to the Lotus XI; the engine is certainly lower but as the wings are the same height and drivers have not changed in size, how is the reduction of frontal area obtained? The driving seat has been inclined to the rear at a greater angle and the cushion is now of synthetic plastic foam, which is only ¼ in thick (7·7 mm) when compressed. It has thus been possible to set the windscreen lower on the body, reducing the height by about 1¼ in (3·2 cm) over the full width. The 1,100 cc Lotus XI with 84 b.h.p. (85 CV) engine reached 151 m.p.h. (243 k.p.h.) so the 15, with engine of 1·5 and 2·2 litres, should have an impressive performance. The dry weight is approximately 980 lb.

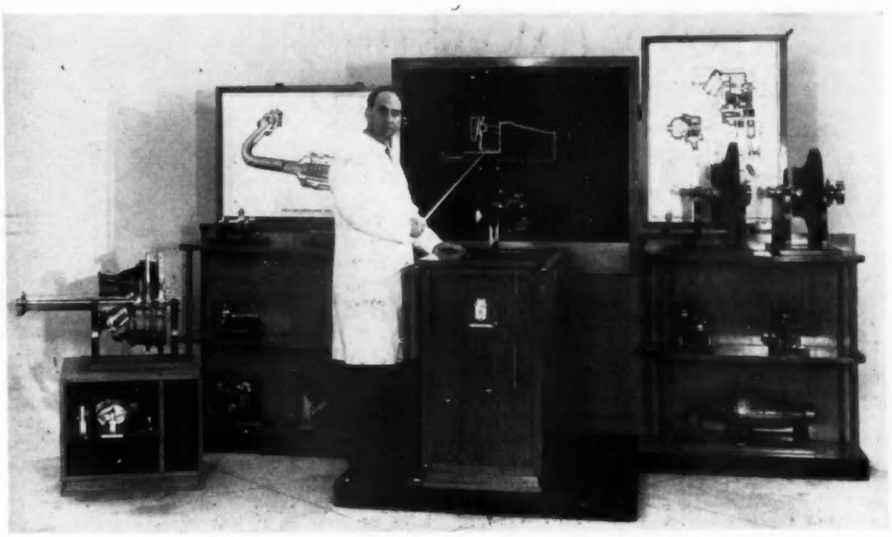
Continuing **Plant and Equipment**

TRANSPORTABLE TRAINING FACILITIES

Rolls-Royce Limited have provided training facilities for users of their cars for many years, and their aero-engine school, started in 1938, was the first of its kind in this country. Since its inception 34,862 students of 59 different nationalities have received training at the school, and it continues to-day to be occupied to capacity. Situated at Derby, near to the main works of the company's Aero Engine Division, the school uses all the customary modern methods of instruction, including visual aids, large diagrams and sectioned models, and has, of course, the full technical resources of the design, development and manufacturing organisation at its disposal. Courses are available for almost every type of man from the aircraft world, the details and lengths of course varying according to requirements. But it was realised by the company some ten years ago that there was also a need for some means of taking the courses to the users, as well as continuing to run the type of course where the users' representatives spend a week or two at Derby. Large users of Rolls-Royce aero-engines, military or civil, may wish to conduct courses of their own, with Rolls-Royce guidance, and in some cases, where the country is large, there may be a need for the training facilities to be taken to different centres from time to time.

The solution provided by Rolls-Royce to this problem is the training aid kit, nearly 80 sets of which have now been supplied for use in various parts of the world. The training aid kit comprises a complete set of instructional material suitable for the initial equipment of a training school; it is similar to that used in the Derby school, but is designed to be transportable. The kit is complete to the last detail, and all the user need do is to provide a room, with seating accommodation, and an instructor, who can, of course, be trained at Derby for the job he has to do.

Basic specifications are kept at Derby for training aid kits for each type of aero engine in production, and also, more recently, for industrial oil engines. On receipt of a customer's order for a kit, a detailed specification, based on the standard one, is drawn up, to include any modification necessary as a result of special conditions particular to the customer. All the equipment is taken to the Derby school for detailed checking before being sent for packing in five substantial cases.



Made in sections, and fully transportable in five cases, the Rolls-Royce training aid kit enables the complete facilities of an aero-engine school to be set up anywhere.

On arrival at its destination the kit is taken from its cases (which are merely for packing and protection, and form no part of it), and assembled. This is done, to a diagram supplied, without tools, each part being made to fit by means of battens or struts.

As the accompanying illustration shows, the kit consists of a base, on which is mounted a desk, with a blackboard at the back, and two diagram frames hinged to the blackboard. Shelves for the display of sectioned components flank the desk. Drawers and pigeon-holes are provided in the central desk for such items as technical notes, trainee notes, folders, lantern slides and a slide projector and tools, and the desk is arranged to give access, through hinged doors, to any or all of the items from either side. Everything kept in the desk is, of course, supplied with the kit, this provision of equipment extending even to such small things as chalk, blackboard duster, and instructor's pointer. The left-hand one of the diagram holders swings inwards in front of the blackboard, and carries a screen, and the top of the desk slides outwards to carry the slide projector at the correct distance. There is even a plug point in the base, for the projector, and it is only necessary for the user to bring an a.c. mains supply to the base.

Details of the equipment supplied vary according to the type of engine it is desired to cover, but a typical specification calls for 20 wall diagrams, for which the diagram holders also act as storage frames, a set of standard tools, such as spanners, a set of special-purpose tools, and a dozen or more sectioned components. Printed matter includes 250 sets of technical notes for trainees, and a technical manual for the engine concerned. Until recently this manual has been of the standard Rolls-Royce type, but in future a new publication based on the specification drawn up by the Air Transport Association of America will be supplied. Finally, there is a note to the instructor, reminding him that the services of the Derby school are his to call upon at any time to answer technical problems.

HANDLING LARGE MISSILES

Small tactical missiles such as are now in service in the armed forces are fairly easy to handle, although the need for rapidly reloading their launcher may demand elaborate conveyor systems; when it comes to handling large space vehicles, however, the problems are of a very different order of magnitude. These questions were considered recently in a lecture given before the British Interplanetary Society in London by Mr. F. R. Forbes Taylor, chairman of the Reed Crane and Hoist Company, on "Problems of Handling Large Missiles," which is summarised below.

In the United Kingdom, the roads and their foundations limit transport to loads weighing not more than about 300 tons, with an upper diameter of 20 ft. In order to launch vehicles which are bigger than this, or which have components of larger size, then at least the final stages of fabrication would have to be done at the launching site. To avoid the complications of erecting a long slender vehicle to a vertical position, ("like standing a ship on end") it would be necessary to build the vehicle in the launching attitude. This reflects on the design of the vehicle and on the assembly schedule; for instance, it would not be easy to mount the engines at the base of a nearly-completed vehicle without hatchways passing right through the propellent tanks. Moreover, far fewer men would be able to work on an upright vehicle than on one lying on its side.

Coming to vehicles which had components weighing 1,000 tons or so, it would be nearly impossible to build a crane, either of the goliath or the dockyard hammerhead types, for assembling the vehicle on its launching pad, primarily because of the difficulties in getting a satisfactory wheel system. For a 1,000 ton crane, capable of building a vehicle 400 ft high, 64 wheels would be needed; an estimated cost is about £3 million. It would be more practical to use an overhead travelling crane, running on fairly low concrete walls, and to carry out the assembly in a pit. Floating cranes, although superficially attractive, are not suitable because of the effects of wind which would make the accurate placing of delicate loads an almost impossible task.

An interesting point which emerged during the discussion is that the British intermediate range ballistic missile is believed to be designed for underground launching, probably not for any reasons of assembly.

ELECTRONIC RECORDER

For Four Ring Balance Meters

The main feature of a new electronic recorder is its ability to receive and record signals from up to four ring balance meters and to integrate them if desired. It is made by the Hagan Corporation (Canada) Limited, Toronto, Ontario, Canada.

The instrument is available as an alternating current bridge, a direct current potentiometer, or a d.c. voltmeter. Each receiver consists of an amplifier, input box, servo motor and a slide wire. Four such units can be installed in a single case. Each input box contains appropriate components for individual measurements. The incoming signals are converted to specific drive signals which are relayed to the amplifier. This in turn drives a reversible shaded-pole motor and a feedback potentiometer to balance the circuit. The same motor drives the linkage for the recording pen. Overall accuracy is within 0·5 per cent of full scale. Both input box and amplifier are plug-in units, and a transistor chopper is included for d.c. application. A wide range of accessories is available.

Continuing **Plant and Equipment**

FORAGE HARVESTING IMPROVED

Towed and powered by a tractor, the Lundell harvester is not only suitable for cutting and loading all kinds of forage crops, it can also be adapted for other harvesting work.

The Lundell forage harvester, which is now being produced in quantity in this country, is of simple design, and calls for very little maintenance other than lubrication and an occasional sharpening of the cutters. Made under licence from John Deere and Company, Moline, Illinois, U.S.A., the machine is being built at the works of Steels Engineering Products Limited, Sunderland, and marketed by Lundell (Great Britain) Limited, Lingfield, Surrey.

It is designed for haulage by tractor, and the cutting unit is driven from the power take-off of the towing vehicle. The drawbar is offset, and the tractor thus rides clear of the crop, which is harvested in an undamaged condition. All kinds of forage can be harvested by the machine, which cuts, chops, lacerates and loads automatically, and can also be used for shredding potato haulms or crops for green manuring. In its standard form the machine is also suitable for picking up and loading straw, leaves, rubbish and waste paper. Output is up to 25 tons per hour, according to the h.p. available from the tractor; normal power requirement is from 35 h.p. upwards.

The machine has a fabricated steel frame and two pneumatic tyred wheels. Connection to the tractor is by an adjustable drawbar, and a universally-jointed shaft is provided for coupling to the power take-off. A bevel gearbox turns the drive to rotate, through V-belts and pulleys, a shaft and blades, extending across the width of the machine, by which the actual crop-cutting is done. The shaft carries 28 swinging flails, to which are attached cutting knives, and these, with a fixed adjustable shear blade, give a cut 4 ft 10 in wide. Running at not less than 1,500 r.p.m. the knives are flung outwards by centrifugal force to form a cutting cylinder with an effective diameter of 2 ft, and the fan action of the flails drives the cut crop up a delivery chute. Each of the flails is mounted by means of a slotted hole on a renewable bush, and on meeting any hard obstruction it will swing back to avoid being damaged. The plate at the back of the cylinder can be adjusted to vary the amount of air drawn in by the flails, and the height of cut can be adjusted between 1 in and 14 in by means of a turnbuckle and quadrant mounting of the wheels. A built-in screw jack enables the weight to be taken off the wheels while this adjustment is made, and also for the wheel track to be varied as required, by sliding the wheel brackets along a square frame member. The same jack serves to line-up the drawbar for coupling to the tractor.

Each cylinder shaft, complete with its 28 flails and knives, is dynamically balanced during manufacture, and the cutting components are made to close weight limits, so that replacements can be made at any time without affecting the shaft balance. Sharpening of the knives can be done in position, by removing the cylinder back plate to give access to them, and using a file, abrasive stone, or portable grinder.

Cut crop is driven by the current of air from the flails up the steeply-inclined delivery chute, which has a swivelling head so that discharge can be into a vehicle towed behind the harvester, or to either side. A crank handle, accessible to the tractor driver, controls the swivelling of the chute by means of a worm gear.

Several attachments are available for increasing the range of work which the machine will do. It can, for example, be fitted with a corn head attachment for collecting maize for silage, or it can be arranged for hay conditioning, when it lays the cut hay in a neat windrow for rapid drying. A conversion unit which is in preparation, and will be available later this year, will enable the machine to be used as a hammer mill. For this purpose half the flails are replaced by grinding hammers, the remaining flails acting as a fan. A cyclone is attached to the end of the delivery chute.

RECONDITIONING LARGE PLUG-VALVES

Large valves are ground-in or lapped by this machine, under automatic control.

The machine illustrated on the left has been supplied to the Esso Petroleum Company, Limited, by the Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware Road, London, N.W.2, for lapping and grinding-in large valves of the plug or cock type.

Of fabricated construction, the machine has an automatically-controlled cycle, which commences by lowering the taper plug, held in a floating mandrel fitted to the machine spindle, into its working position in the housing. In this position the plug is spring loaded against the housing, which is held rigidly on the machine table. As soon as the plug has reached its working position, the spindle starts an alternating clockwise and overlapping anti-clockwise movement, simulating the type of motion used in hand lapping. An automatic timer is pre-set to stop the machine when the grinding or lapping is finished.

FILING AND SHAPING

Introduced by Stanley Works (G.B.), Limited, Rutland Road, Sheffield 3, the Stanley " Discut " filing machine is of the disc type, and is designed especially for dealing with materials such as non-ferrous metals, plastics, wood, leather, and hard rubber, which are not readily cut by grinding wheels and other conventional methods.

The non-clog disc, 10 in in diameter, is of thin steel, supported by a backing plate, which has spokes arranged so as to act as a fan, and draw air between the teeth and keep the disc cool. A smooth finish is imparted by the machine, and as the material is removed in the form of chips rather than dust, extraction apparatus is usually unnecessary. For general applications the speed of the disc is 400 r.p.m., but other speeds will be considered by the makers. The machine is available for any standard electrical supply, and as a bench or pedestal model according to choice.

The Stanley " Discut " filing machine is designed for a large range of materials which do not lend themselves to grinding or other conventional machining methods.

For the FACTORY

THE sixth Factory Equipment Exhibition held at Earls Court, London, closed on 19 April. At the official opening, Sir David Eccles congratulated British industry on the progress made since the war and in particular praised the work of the Productivity Council for their share in the achievement. Some of the items on show were described in our issue of 18 April (p. 486) and some more are mentioned below.

ROOF BREATHERS

With the advent of better insulation for roofs and buildings generally, the problem of condensation of moisture is becoming more acute. Moisture collecting below an impervious roofing material such as asphalt, causes the latter to bubble and crack as a result of heating and cooling. A device designed to allow moisture to escape from below asphalt layers was shown on the stand of Paramount Asphalte Limited, 149 Kennington Park Road, London, S.E.11. One of these "Parovents" is shown in Fig. 1. This is the design for flat roofs or for those which are slightly cambered from the centre. They should be mounted on the highest point.

Beneath the vent the screed layer, if any, should be cut away to expose the insulation layer and this should be dished. The asphalt and underlay, or the layers of bitumenised felt,

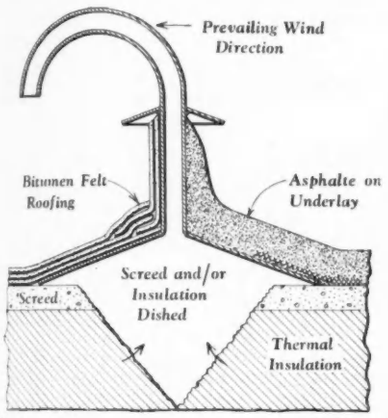


Fig. 1 The "Parovent" is intended to allow the escape of moisture from below an impervious roof layer.

whichever is being used for the roof in question, are then laid over the base cone and drawn up the stem almost to the upper cone. The bent outlet funnel should be turned in the direction of the prevailing wind. The spacing should be about one vent per 20 sq. yd. The device is made of copper, 17 s.w.g., for the funnel and 16 s.w.g. for the base cone and cowl. The serrations on the base cone allow breathing to and from the funnel. Two other forms are available for other types of roof construction.

BOILERS

Edwin Danks and Company (Oldbury) Limited, 7 Tavistock Square, London, W.C.1, were showing several forms of boilers and burners. One of them was a corner tube unit for high-pressure hot water and process systems. Models in this range are available in standard sizes with outputs from 2½ to 20 million B.t.u. per hour, fired by oil, solid fuel (using a chain grate stoker) or waste gas. They are completely welded structures with the downcomers, distribution and collector tubes interconnected to form a tubular framework strong enough to carry the heating surfaces, the setting and the casing. Although this type of boiler has an inherent natural circulation, in these models it is pump assisted. Other advantages of the type and of these units in particular are high specific output, low draught loss through the chamber and the absence of expansion joints.

STRUCTURAL ANGLE

Although it cannot actually be classed as factory equipment, one of the main items of interest was the Gassiot rocket "Skylark" shown on the stand of Chevron Structural Units Limited, 7 Victoria Street, London, S.W.1. Around the rocket was a staging built of Chevron angle. The Skylark, 25 ft 7 in long, is a rocket designed for investigating the upper atmosphere in connection with the programme of the International Geophysical Year. It is propelled by a solid fuel motor. New additions to the range of Chevron products also on the stand were: cleats for use as feet or for timber shelves; plastics end-covers fitting over the ends of sections to prevent the marking of floor surfaces; and studs for the rapid positioning of shelves without the nuisance of nuts and bolts. An example of construction was a rack for oil drums fitted with an arrester gate so that the drums can be removed singly. The drums roll towards the gate under gravity along sloping rails and can be loaded or removed by fork trucks.

EXTENDING TOWER

The latest addition to the range of Zip-Up staging was shown on the stand of Access Equipment Limited, Maylands Avenue, Hemel Hempstead, Hertfordshire. The "Tallescope" is available in three working heights: 21 ft, 26 ft and 31 ft; all can be collapsed and folded to pass through a 30 in wide doorway. As shown in the illustration Fig. 2, a flat surface is not necessary for them to stand on—the adjustable legs allow their use on steps or slopes.

The structure is made of aluminium, and consists of three main components which can be assembled to form the tower in 1½ minutes. For passing through doorways the tower retracts and folds to lie horizontally. The large rubber castors are fitted with locking mechanisms to prevent either swivelling or rolling once the tower has been positioned. The legs can be extended sufficiently to span fixed seats or other similar obstacles. On the top of the tower is the working platform and this has a guard rail right round it so that the operator can have both hands free for work. The height can be adjusted by hand, rendering the unit independent of any power supply.

STOCK MARKING

Stock of all types requires marking, and for most purposes this means some method of attaching a label. Designed for the job is the Gripson system for permanent or temporary marking displayed on the stand of Adapta Charts Limited, 129 Hammersmith Road, London, W.14. The system consists of black oblong interlocking units, ¾ in high, which are heat-embossed with white letters and numerals. These are linked together in any desired combination and then have a double-sided adhesive tape applied to the back. The tape will adhere to any dust-free surface and can be removed if desired without causing damage, even to varnish or paint.

The system is available in sets of 270 units (either letters or numbers) together with 36 front and 36 end pieces and a 10 ft coil of tape. Spare characters are available. The units can be washed after use and will last indefinitely.

STAFF CALL

A recent addition to the many staff location systems that exist is the "Selectacall" individual call unit that was demonstrated on the stand of the Westrex Company Limited, Liberty House, Regent Street, London, W.1. The system consists of a loop aerial fed from a central transmitter, and pocket units for the staff members. Control units are made in two standard sizes, for 50 and 100 circuits respectively. The average area that can be covered by a transmitter without additional amplification is about 120,000 sq. ft.

The smaller control unit measures 12½ in by 7 in by 6¼ in and has twelve keys. These are used two at a time to select the required channel. The call key is then depressed, which automatically transmits a series of pips for 7 sec. At the end of this period a lamp lights and the message is spoken into the microphone. The transmitter unit measures 20 in by 10 in by 11 in and can be located in any convenient position; its operation is entirely automatic. The receiver units weigh 5¼ oz and measure 5¼ in by 2⅛ in by ¾ in. Battery costs amount to about ¼*d.* per week of 40 hours. After the warning pips have been received, the message is heard by placing the receiver close to the ear and pressing a button. This affords a reasonable degree of

Fig. 2 The "Tallescope" extendable tower can stand on steps or uneven ground and folds to pass through a 30 in doorway.

privacy and also allows the unit to be used satisfactorily in areas of high noise level.

PACKAGED STEAM GENERATOR

A packaged steam generator made under licence from the Vapor International Corporation was one of the items on the stand of J. Stone and Company (Deptford) Limited, Deptford, London, S.E.14. These units are oil fired and have weight/capacity ratios as low as 1·29 to 1. The four standard models have steam outputs from 1,000 to 4,500 lb per hour from feed water at 60° F. From cold, a pressure of 200 lb per sq. in can be attained in 2 min. Operating pressures are from 50 to 300 lb per sq. in as a rule, but special models can be supplied to work up to 600 lb per sq. in.

These units work on the "once through" principle with the fire adjusted to evaporate 90 per cent of the feed. The water remaining helps to scour the coils before being separated out, leaving the outgoing steam with a dryness fraction of 0·99. Once the set pressure is reached, the operation is automatic according to the demand; the burner adjustment allows a reduction to 20 per cent of capacity with a continuous flame, and down to zero when cycling on and off. Over the output range the efficiency varies from 78 to 83 per cent.

REPORT FROM BRUSSELS

Science, Engineering, and Showmanship

The International Hall of Science is both the beginning and the end of the Brussels Universal and International Exhibition—engineering links the two points. The hall is the beginning because basic scientific facts and equipment are displayed there: without these as a starting point there would be no exhibition. It is the end because it points to further engineering progress.

Various interpretations have been made of the function of the Exhibition. One theme put forward officially is "A World Balance Sheet for a More Humane World." An alternative is "Man: His Achievement and His Aspirations." The latter gives a better picture of what the Exhibition is like. Achievement surrounds the visitor, and aspiration is sometimes shown to him; but he must draw up his own balance sheet.

The engineering achievement in construction alone is impressive. About 1,000,000 cu. yd of earth have been displaced to set the buildings down in 500 acres to the north of Brussels. Some 12,000 workers have been employed for a total of 60,000,000 hours. The buildings and the pavilions have a surface area of about 1,200,000 sq. yd and contain 30,000 tons of metal framework. The installed electrical capacity is over 60 MW. It will probably be a month or so before all the exhibits are ready.

Inside the completed pavilions, various aspects of engineering achievment can be seen. Most of the larger national pavilions have given space for the display of the particular branches of technology to which they owe their prosperity. The large Belgian section, for example, has several buildings given over to particular aspects of Belgian engineering—such as the Electrical Power Pavilion, or the Metallurgy Pavilion. Some large industrial firms have their own pavilions for the display of their equipment. There is an international pavilion devoted to transport, and transport and power also feature in the Pavilion of World Co-operation. In addition the structural features of many of the pavilions themselves provide a display of civil engineering that extends over the whole site.

At such an exhibition the display of scientific and technological achievements raises several problems. The Universal and International Exhibition is no trade fair. One of the difficulties is the variety of spectators. Some have technical knowledge, many have none. To such people the exhibitor must convey the skill with which technical problems have been overcome. He must also make sure that it is clear why any effort was called for in the first place. The public should not get the impression that great pains are taken to solve trivial problems.

Sometimes another unknown quantity exists between the spectator and the engineer: the stand designer. It is unfortunate that in some cases he may not understand the equipment that he is arranging. In which case he might produce a very attractive display that will delight the eye of the onlooker but distort the engineering achievement. Mystery might be created where none exists.

At Brussels the variety of exhibitors and exhibits gives ample opportunity for study of the different attitudes towards the display of technical advance. The Atomium, the French Pavilion, and the Belgian civil engineering exhibit, are remarkable examples of constructional achievement. Reactions to them are diverse. Some people welcome them as good to look at, new, and indicative of man's power over materials. Others take the opposite view and ask why such things should be built at all, and question the wisdom of devoting so much effort on self-imposed problems. Yet rebukes such as these can be made not only to engineers and designers: four-minute milers and Everest climbers must face the same criticism. All feel the challenge to explore the limits of man's capabilities. This end is looked on as its own justification.

PRESENTING THE NEUTRINO

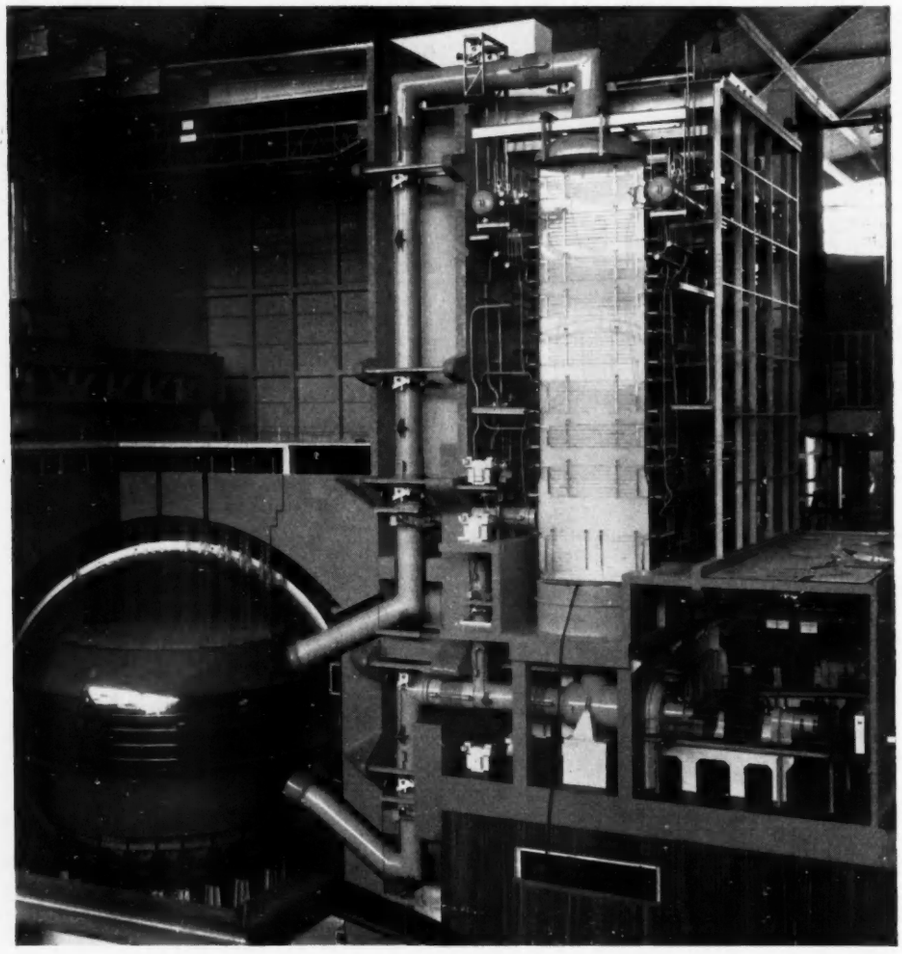
As most people can appreciate structure and balance, the general onlooker can judge the value of the three structures mentioned above merely by looking at them. The technically minded will be interested in the developments that such structures foreshadow. But there are other exhibits of a more abstruse nature that the layman might well dismiss as scientific hugger-mugger instead of recognising their value. For example, what will the general onlooker think when he learns, in the International Hall of Science, about work on the neutrino. He reads that it has probably no mass, no electric charge, spins clockwise, and probably travels through the universe for ever without hitting anything. He will then see the complex experiment devised to detect the effects of this long-travelling nothing and might well, on reflection, think the whole exhibit a scientific leg-pull.

But as he will have already seen exhibits concerning the simplified film theory of interphase mass transfer, the cytology and genetics of hymenomycetes, the pinning of crystal dislocations by neutrons, and the martensitic phase change in gold-cadmium alloy, he will probably retain his equanimity. He might perhaps be concerned on learning that 10^{14} neutrinos pass through his body every second from the sun, but he will probably balance this against a statistic picked up at an earlier exhibit, namely, that a cube of sugar represents the energy of sunlight falling on 1·5 sq. metres of the earth's surface per minute.

The International Hall of Science is mainly for the technically minded. To them it will be of considerable value, for it brings together a wide variety of developments in different fields of research. However, considerable time is needed to get around all the exhibits. There are four main sections: the atom, the crystal, the molecule and the living cell. As one enters at the "Atom," one passes a cinema where 600 people can watch a film dealing with the phenomena of matter up to life itself. In three small rooms that seat about 100 people, further short films are run.

The exhibits in the hall vary from simple explanatory diagrams and models to full-scale items of equipment such as mass spectrometers. The explanations printed alongside the exhibits vary too. Some demand considerable background knowledge if they are to be understood. Others are more lucid. Several simple mechanical analogues of cyclotrons, linear accelerators, and cascade generators show the principles of the larger complex machines very clearly.

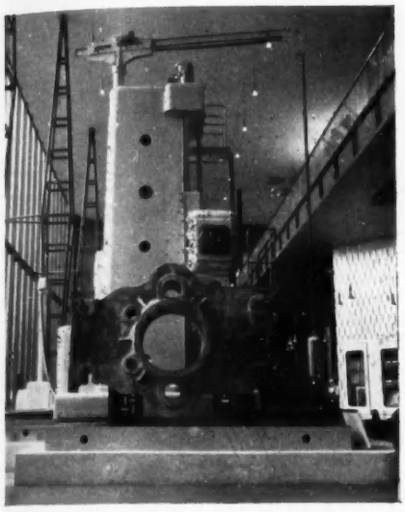
Other exhibits invite the participation of the spectator. There is a large diagram, for example, with a telephone dial at its base: the spectator can dial the atomic number of an element and an illuminated display of the relative abundance of the existing isotopes appears. Another diagram



The visitor can almost get inside this nuclear power station model in the British industries pavilion.

sets out the properties of the various nuclear particles that are known to exist.

The hydrogen fuel cell is an exhibit at the start of the molecule section. Electricity is generated directly, by the electrochemical oxidation of hydrogen, the reaction being catalysed by special carbon electrodes in an alkaline electrolyte. An efficiency approaching 100 per cent is claimed. An alternative means of energy conversion is shown in an exhibit concerned with much larger molecules. The model shows the chemically-induced lengthening and shortening of a filament containing polyacrylic acid. The contraction is used to lift a weight. A second model shows the probable structure of polyacrylic acid, which has the formula C_{1500} H_{2000} O_{1000}.



This horizontal boring machine forms an impressive monument in the Czech pavilion.

In an alkaline bath with a pH of 12, lengthening occurs; on the addition of hydrochloric acid until the pH values reaches 2, shortening occurs. The cycle can be repeated indefinitely and the result is that chemical energy is converted directly into mechanical energy, in a manner analagous to muscular contraction.

Among the other exhibits concerning macromolecules, are a rubber heat pump and silicone putty. The latter is shown flowing like viscous fluid through a glass funnel. On emerging from the funnel it falls into a vibrating beaker where it bounces like a rubber ball. These are rate effects due to a spectrum of relaxation times.

Of more immediate practical use is the solar generator shown in another part of the hall. The model, to a third full size, is of equipment intended to produce steam at 165° C and 6 atmospheres pressure. In the display an electric light bulb is used in place of the sun, but a small steam engine is driven. Two improvements over previous solar generators are claimed: a superior absorbing surface of low emissivity (0·1 compared with 0·95 for normal black); and an inverted horizontal collector that cuts down convection losses by a factor of 5. These developments allow the use of a simple non-moving low power mirror. The full-scale units are connected in series running from east to west. Five units, each of 6 sq. m mirror area, will run a small pumping station; 500 units should save 300 tons of fuel oil a year in Israel.

A working exhibit that is not a model is the training reactor in the atom section. This is normally operated at a nominal power of 1 watt, although it has reached 1 kW on transients. It is used for giving students practical experience of reactor handling. Neutron counts can be made by them and they are able to check over the functioning of the safety circuits.

Models of nuclear reactors appear in several pavilions, but probably the most impressive is the very large one, shown opposite, of a complete 400 MW nuclear power station, including turbines and switchgear, in the British Industries pavilion.

The model, which is one-twelfth full scale, occupies the whole of the stand. Along the front are the buildings for the gas-cooled graphite-moderated reactors. Ground level is at eye level for the spectator. At one end of the reactor building a heat exchanger and reactor are partially sectioned, the reactor being contained in a perspex hemisphere. Periodically the control rods are removed from the core which then glows red; at the same time flow in the heat exchangers is visible. Visitors can walk across the raised area between the reactor and generator buildings. Inside the latter is a full layout of equipment. At the back of the stand, switchgear and associated transmission equipment complete the display.

The detail shown in the model illustrates quite clearly the advanced state of the British nuclear power programme compared with those of other countries. In the United States pavilion there is a large simple wall diagram of a 134 MW pressurised water reactor that is being designed and built for an American power company. Other smaller diagrams show the following reactors, all said to be producing electricity: a boiling water reactor in California, a sodium-cooled reactor in California, a pressurised water reactor in Pennsylvania, a homogeneous reactor in Tennessee, and a breeder reactor in Idaho. The largest part of the American atomic section is given over to a working manipulator for the handling of toxic and radioactive materials. A cutaway model of the proposed nuclear power ship Savannah is also shown. The reactor is situated amidships.

TRIBUTES TO INDUSTRY

In fact, the Americans have avoided displaying exhibits of engineering achievement except in the most superficial form. The explanation put forward by the United States Deputy Commissioner General to the Exhibition was, " As you are well aware, the world already is cognisant of our industrial and economic strength. Therefore there is no heavy machinery or implements in our pavilion. There are no statistics of our industrial production. There are no charts of American business. Instead we are employing a distinctive method to reflect the cultural, artistic and technological aspects of America."

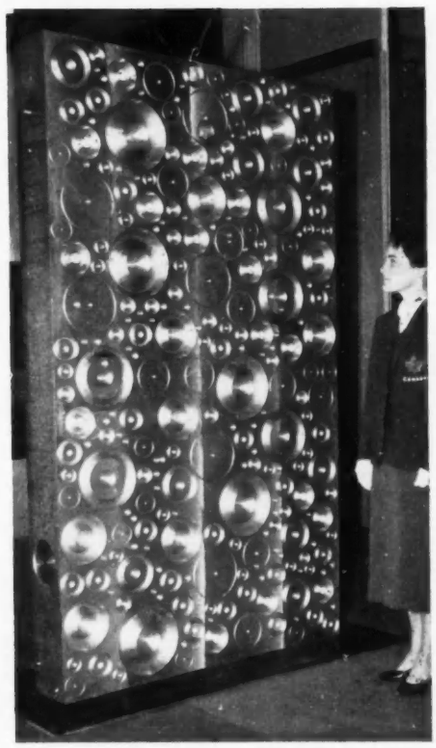
The nuclear power exhibit in the Soviet pavilion is set out in a section of one of the side galleries. Models are displayed of the first power producing reactor made by the Russians, a fast breeder reactor using liquid sodium coolant and developing an electrical power of 50 MW, and a power station using two pressurised water reactors, each developing 210 MW. The last is under construction in European Russia and should be completed in 1960. There is also a model of the nuclear-powered icebreaker, Lenin.

At the opening, the Russian technical exhibits were characterised by lack of explanatory captions; this may be remedied later. However, most of the stands are very well equipped with technical staff to answer visitor's inquiries. In the main hall of the pavilion a great deal of prominence is given to machine tools. They stand in groups on either side of the main aisle and though they are of considerable technical interest they are arranged in a very unimaginative manner. One of the items is a vertical three-dimensional milling machine that operates from magnetic tape. The programme device that reads the tape and operates the tool is transistorised. In the preparation of the tape, linear interpolation is used between the fixed co-ordinates of the working drawing. The tool has a longitudinal travel of 1 metre, a transverse travel of ½ metre, and a vertical travel of 400 mm. Another stand features equipment from automatic production lines, including two lathes operating face to face to avoid turning the workpiece over, a machine that automatically checks the balance of electric motor rotors and then drills them to produce a balance within 5 to 10 per cent of true, and a vertical multi-spindle lathe with six individual spindle groups and automatic loading. The last is shown set up for producing shafts for gearboxes; it has a mixed hydraulic-electric control system. Also shown is a precision jig boring machine in which optical devices are used to set the co-ordinates; an accuracy of 0·01 mm in 1 metre length is claimed for the positioning of hole centres.

A far more imaginative arrangement of machine tools for display is to be found in the Czechoslovakian pavilion. There architecture, light, and surface colour have been combined to good effect in a hall that houses two very large machine tools and various smaller items of industrial equipment. The biggest item is the WD 200 horizontal boring machine in which all functions are remote controlled; a work spindle of 200 mm diameter can be employed and the maximum spindle boring depth is 2,000 mm. The maximum travel of the sleeve is 1,600 mm. A main motor of 35 kW is incorporated.

Entering the pavilion, the visitor approaching the industrial exhibits first meets a working model of the hydro-electric installation under construction at Orlik in Bohemia. The scale is one-seventieth full size and cutaway sections show water operating the turbines. Four turbine units provide a total output of 360 MW. Outside the pavilion one of the turbine wheels, to be installed at the finish of the exhibition, hangs turning on its axis. A second large exhibit greeting the visitor is a full-scale industrial betatron installation. This is for the inspection of large machine parts with 15 MeV gamma rays. Port-holes and industrial television monitors allow the interior to be studied from various angles.

These two large items stand in an annexe to the main hall containing the machine tools. High up on the walls of the annex three coloured films can be projected simultaneously; with the



Another example of the monumental approach is this aluminium ingot.

accompaniment of electronic music they portray aspects of Czech power generation. Together, the hall and the annex give an excellent display of engineering.

Naturally, in each national pavilion many of the exhibits bring out the characteristics of the country and its people. In the Dutch pavilion

Continuing Report from Brussels

water and sea are not only emphasised by the architecture, which employs many pools and streams, but also by the two large wavemaking installations. One is mainly decorative and produces small waves in a rectangular pool near the centre of the site. The other consists of a glass-sided tank in which large waves are produced to test their effect on dyke construction. The waves thunder realistically on to a sloping dyke and various transducers feed information concerning pressure and velocity to electrical recording equipment.

In the Swiss pavilion there are exhibits of scientific instruments—such as a precision level with an accuracy of $\pm$ 0·01 inch in one mile at a single levelling—electric power, and chronometry. An atomic clock is shown which uses an ammonia oscillator at 24 kMc/s as its standard; a klystron is used in a frequency control circuit, and a quartz crystal provides a secondary reference. Among the industrial exhibits is a very small automatic lathe for producing precision machine parts. Small screws—8,520 go into a thimble—can be produced from brass rod at the rate of 22 per minute.

Japan has one of the smaller pavilions and has managed to use the fact to some advantage by having a unifying theme throughout. The theme is " The Japanese hand, and the machine." Photographs and murals show the intricacy of Japanese handwork in the past. Then the present is depicted, with emphasis on the fact that the machine age still calls for skill. The remarkable six element *f* 1·1 Nikkor camera lens is shown, and, rather confusingly, a diagram of a five element Cannon *f* 1·2 lens is shown alongside. The biggest exhibit is a diesel tipping truck. Complexity is illustrated by electronic analogue computers and electron microscopes.

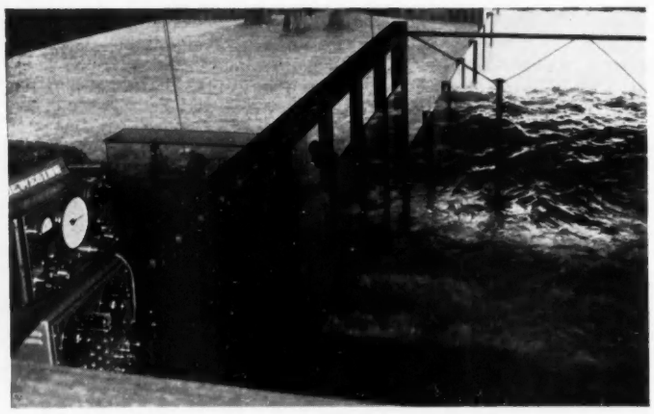
POWER CAVERN

In general, where it has been possible to present a unified theme, a room or pavilion has been more successful. Some of the engineering pavilions in the Belgian section, although of a national character rather than illustrative of the present position of engineering in the international sense, show a high degree of skill in display. The inside of the pavilion of electrical energy resembles a large sombre cavern, the exhibits being illuminated by various striking plays of light. The pavilion is, in fact, a large rectangular hall with two entrances, one through a restaurant. Aluminium channelling covers the 400 ft façade. On coming into the entrance hall the visitor sees diagrams giving the connections between the main authorities concerned with electrical power and distribution in Belgium. In the main hall the visitor sees the various forms of electrical generation set out as models. Also near the entrance is a sectioned hydrogen-cooled alternator with an output of 125 MW. Near the centre of the hall is a 2 MV installation producing large electrical discharges. In the gloom the effects are spectacular. Towards the far end of the pavilion the various means of using electricity are shown, a large space being given over to applications of electronics.

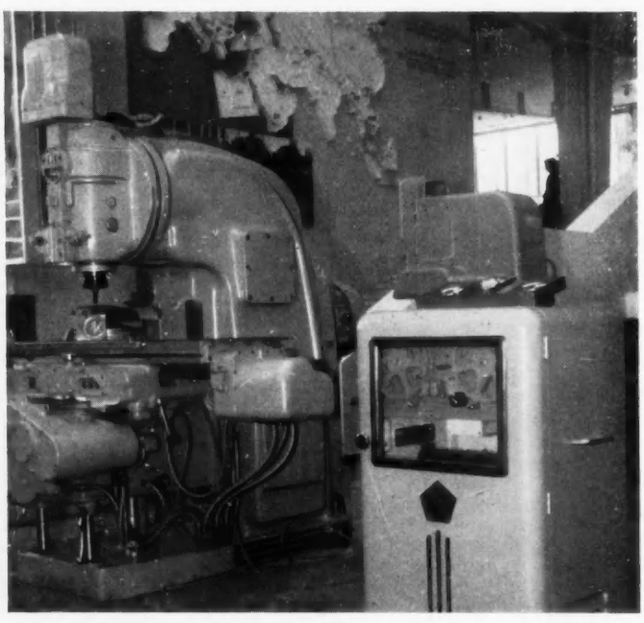
One of the common difficulties facing engineering exhibitors is that a piece of highly intricate and skilfully built equipment may often have a very simple exterior. Much electronic equipment, for example, merely looks like a well finished box. In the Hungarian pavilion there are several items of equipment that come into this category. A high-precision optical exhibit measures the velocity of light and detects light energies in various parts of the spectrum to intensities of 100 photons per second, or 10^{-18} watts. The velocity is measured by timing the light over a path of 3 m and time intervals of 10^{-8} sec are involved. To give some idea of what the box does the exhibitors have placed a simple diagram over it giving the salient facts.

In the Canadian pavilion, aluminium is featured in the industrial section. Other countries such as Switzerland have also featured this metal, mainly by showing examples of its use in engines, structures, etc.; however, the Canadian exhibit centres on a large rectangular ingot, weighing 5,000 lb and machined all over to give a sculptured effect. Canada, unlike the United States, has set out a good many statistics about her industry and people. Another outlook is presented by Venezuela. Their Commissioner General explains: " In the Venezuelan pavilion you will not find machines nor samples of craftsmanship; every thing is exhibited to give the accurate impression of all the opportunities the country offers for investment and labour; to stimulate and aid anyone who considers Venezuela as a future field for his activities."

In fact there is, throughout the exhibition, a contrast in attitudes from pavilion to pavilion as to which aspects of engineering should be exhibited, or whether any should be exhibited at all. For the visitor who has the leisure to visit all the pavilions, this variety is a fascination in itself. But as far as drawing up a balance sheet of man's achievements is concerned, it would have been a great advantage to have an international hall of engineering to complement that of science.



A large exhibit in the Dutch pavilion, which showed many influences of the sea, was a wave making installation complete with recording equipment.



A magnetic tape controlled three-dimensional milling machine was displayed by the Russians. The tape reader is transistorised.

The two parts of the diagram show the functions carried out by the optical equipment. In this way the linguistic barrier is bypassed.

Companies in the News

Trends in Compressed Air

The rate of expansion of the compressed air equipment industry is slowing down. This is the general conclusion reached by the Council of the British Compressed Air Society in their annual report for 1957. They point out that the value of deliveries of compressors and exhausters in 1957 was 11 per cent greater than in 1956, whereas in that year the increase had been one of 15 per cent. If changes in price are taken into account, the increase in physical output last year is unlikely to have been more than 5 per cent. Orders on hand were 10 per cent lower at the end of last year than at the end of 1956. Orders outstanding for pneumatic tools fell by 20 per cent over the same period and the value of deliveries was slightly lower. Only in the field of paint-spray equipment has the order position improved.

At the Society's annual luncheon last week Mr. F. J. Erroll, Parliamentary Secretary, Board of Trade, told members that they would have to live with the credit squeeze for a while yet. He congratulated the industry on its export performance—£8 million out of a turnover of £21 million—and expressed his faith in their long-term future; he also called the need to export " the outstanding challenge of our time " and talked of the Government's efforts to liberalise trade. On the European free trade area, Mr. Erroll expressed the hope of a successful outcome for " what is at stake in the negotiations is not only trading relationships in Western Europe, but the very much wider political implications for the future co-operation among Western European countries in every sphere of economic and political activity." The BCAS Council have already begun to study the implications of the European common market and have established contact with Western European organisations of manufacturers of compressed air equipment.

American Aircraft, Missiles and Atomics

The considerable advantage held by the United States aircraft industry over its British and Continental competitors is revealed in the annual report of the Martin Company, makers of the inter-continental ballistic missiles Vanguard, Titan, Matador, Bullpup, and a most impressive range of control equipment and aircraft. Their president, Mr. George M. Bunker, told a story of startling successes in his annual report to shareholders. Sales in 1957 at 427 million dol were 18 per cent higher than in 1956, and the largest in the history except for the war years 1943 and 1944. The backlog of business on contracts at the end of last year amounted to 795 million dol, of which approximately 60 per cent consisted of missiles and associated equipment. Over 28 million dol was spent during 1957 on expansion and modernisation, including considerable new facilities near Orlando in Florida. Employment fell by nearly 2,000 to 27,269 indicating that increased efficiency was a big factor in the higher turnover.

Commenting on the substantial increase in the company's manufacturing facilities, Mr. Bunker expressed the hope of adding during the current year both to the present backlog of orders and to the potential volume for future years. Martin are moving in the field of electronics and nuclear energy which should in due course make them something more than " a weapon systems contractor capable of designing, managing and producing efficiently." Of particular importance is the production for the army of the Missile Master system, which is an electronic defence system the first of which was put into action last December. This automatic system for transmission and co-ordination of information is considered of the utmost importance as a factor against air attacks, and the next to become operational will be for the New York City Defence, and for the strategic industrial and population centres across the United States.

Martin have not limited themselves to the aircraft and missiles field. The company are spending large sums on basic research and have recently moved their fundamental research centre, RIAS, Inc., to new headquarters selected " to provide an atmosphere more conducive to the quiet thought and intense work required for the advance of creative pure science." Among projects under development are a 12,500 kW nuclear power station employing a pressurised water reactor and a 1,000 to 2,000 kW portable power plant which can be transported by air.

Gas Retort

The new techniques of gas making, using cheaper grades of coal and oil as basic raw materials, were described as " revolutionary " by the chairman of Parkinson Cowan Limited, Mr. Hugh P. Barker. " These developments will succeed " he told shareholders at the company's annual meeting, " and, as the years go by, manufactured gas of superior physical properties and at very competitive prices will arrive on the domestic and industrial scene." Mr. Barker then expects the gas industry, the progress of which has been arrested " in a squeeze between the rising price of coal, to which it is very sensitive, and the developing ubiquity of electricity and liquid fuel," to resume its upward climb.

The manufacture of gas appliances and meters forms about half the activity of the company. Some of these, of course, are for industry but as domestic appliances account for half their total turnover, they are vitally concerned with the competitive ability of gas for cooking and space heating purposes. The reduction of the purchase tax on all household gas and electric appliances from 60 per cent to 30 per cent will help Parkinson Cowan, although the mainstay of their home equipment trade, the gas cookers, were already exempt. Equally it will help makers of electrical appliances and is unlikely therefore to arrest gas loss of ground to other fuels. The imposition of a 30 per cent tax on paraffin burning space heaters will hit the company, who have established themselves among the leading manufacturers of these appliances. Parkinson, however, are well diversified. They make a washing machine (the first to embody the " live water " principle, with no moving parts in the tub), spin dryers and other electrical appliances. Some 40 per cent of their turnover is in metering and instrumentation, including fluid meters and " fluid automation "; metering of gases; and electrical control and instrumentation. Their development of radiant heating by gas for industry is another of their newer activities.

Radiation Limited, who are one of Parkinson Cowan's main competitors in the domestic appliance field, have experienced the same difficulties at home and abroad. Trading restrictions are their main enemy. Mr. W. Donald King, their chairman, expects 1958 to be " a year of hard struggle," though he sees signs " that the rate of increase in costs is slowing down." Mr. Barker also takes the view that the prospects for the current year, which " has started indifferently," are poor. " We are," he said, " fighting an atmosphere of recession by a much increased activity." This is an apt summary of the industry's position.

Unrewarding Expansion

Two American companies, one of them a British subsidiary, have suffered through rapid expansion from sharp consequent increases in fixed charges. Vauxhall Motors, who have practically completed the £36 million expansion programme which they began in 1954, made a trading loss of £1·13 million (compared to a profit of £3·93 million in 1956) despite an increase of nearly £5 million in turnover, to £76 million for the year. Cummins Engine, Inc., of Columbus Indiana—who began last year to manufacture (initially to assemble) their diesel engines at Shotts in Scotland—had record sales, but a 10 per cent drop in net income. In their case a general rise in costs, and particularly for the promotion of sales, was the major factor.

Vauxhall Motors' report for the year, presented jointly by their chairman, Mr. G. N. Vansittart, and their managing director, Mr. Philip W. Copelin, looks on 1957 as " a period of great development which will result in a major increase in the size, importance and efficiency of the company." Their loss was due to the inadequate rise in output to absorb the higher fixed charges arising from the vast investment in new manufacturing resources. In addition, there were heavy production development costs arising from the introduction of new models " on a scale never previously achieved in one year," due to delays in the delivery of many items of new equipment on which the expansion programme depended and to the need for training a large intake of new employees (employment rose by 6,000 during the year to 22,000). Also demand for the new Victor car did not come up to expectations, though it is now gathering momentum. Clearly the board anticipate a very much higher level of activity in the future and look upon 1957 as a period of transition.

Cummins were beginning to feel in 1957 the softening in demand which developed in 1958. The directors were unable to make a forecast of sales and earnings for the year and clearly expect it to be far worse, though they have evidence that the company are increasing their share in each of their principal markets. It is a long-term expectation of growth on which they base their optimistic outlook, giving three main reasons: the switch from petrol to diesel power in road transport in the United States; the extensive American road construction programme; and finally " the fast growing world population."

Switchgear on Top

Few chairmen of companies have been in a position in recent weeks to give their shareholders as confident a forecast of prospects as Sir Claude Gibb, of A. Reyrolle & Co. Orders obtained in 1957 constituted a record and were spread evenly over the company's complete range, thus giving a well balanced load on production facilities and making a record output possible. Sir Claude finds it " more difficult to-day than a few years ago " to predict the near future, but the longer prospects of expanding business " remain unchanged." Nothing in his statement suggested that his company anticipate an immediate reduction of business, despite growing competition, the world-wide recession in trade and " the imponderables of the European free trade area if one is established."

The small fall in demand which took place towards the end of last year and affected most switchgear makers appeared to taper off over the past two to three months. Competition is much keener, however, and there is no doubt that some firms have been affected far more than others.

Membership of the Nuclear Power Plant consortium has enabled Reyrolle to work closely with them in the development of nuclear power plant. Their contribution to the NPPC exhibit at Brussels—a scale model of a 400 MW nuclear power station—has been the central control room, auxiliary switchgear and main 132 kV switchgear. In addition, Reyrolle have interests in the Anglo Great Lakes Corporation, who are building a factory at Newburn-on-Tyne to manufacture graphite of the special quality required for reactors. Reyrolle undertook to do the machining and have installed special equipment for this purpose in an air-conditioned shop at Newburn. A major extension of several bays at the Hebburn works should also be in full use by the end of this year.

In Parliament

FOREIGN APPRENTICESHIPS

There was a discussion in the House of Commons last week on schemes of apprenticeship in foreign countries. It arose out of a question asked by Mr. R. Moss (Labour), in which he inquired as to the steps being taken by the Minister of Labour and National Service to collect and disseminate in this country information in respect of such schemes.

Mr. Richard Wood, who has succeeded Mr. Robert Carr as Parliamentary Secretary to the Ministry of Labour, replied that articles on foreign apprenticeship schemes appeared from time to time in the publications of the International Labour Office. These publications were available in Britain and, in addition, the Ministry had information regarding schemes in certain countries. In recommending the establishment of a National Apprenticeship Council, the report of the Carr Committee *Training for Skill* (H.M.S.O., 2*s*. 6*d*.) had suggested, as one function for such a body, the collection and distribution of information to industry on apprenticeship and training arrangements, both in Britain and abroad.

Mr. W. Ross (Labour) said that paragraph 18 of that report had asked that somebody should collect and disseminate information by other means as well as by articles in magazines. These proposals, Mr. Wood said, were being studied by the Ministry's National Joint Advisory Council, and he looked forward to reporting on the matter on a future occasion.

TRADE UNIONISM IN BANKS

The attention of the Minister of Labour was drawn by Mr. G. M. Thomson (Labour) to a petition from Scottish bank employees appealing to him to persuade the managements of the Royal Bank of Scotland and the British Linen Bank to meet representatives of the National Union of Bank Employees, in order to discuss the setting up of mutually-acceptable negotiating machinery. Mr. Thomson stressed that the petition had been signed by 72 per cent of the employees of the former bank and by 76 per cent of the latter. A similar question was asked by Mr. E. G. Willis (Labour).

Mr. Iain Macleod said that, in effect, the petitions were asking that the banks should recognise the National Union of Bank Employees. The matter was one for the employers but he had arranged that the Ministry's chief industrial relations officer in Scotland should bring the petitions to the notice of the banks with a view to discussing the position with them. It was certainly true that the question of union recognition had been going on for a long time. It was also true that recently a substantial additional number of bank employees had joined the NUBE, and that fact was a very relevant one. At the same time, the case was one of real difficulty and no Minister of Labour ever laid down to employers which organisations they should recognise. If circumstances were to arise in which a Minister of Labour were to lay down to employers, or to anyone else, whom they should recognise, it would seem to be an impossible position to maintain.

UNEMPLOYMENT IN SCOTLAND

Mr. Macleod told the House that the latest available unemployment figures for 17 March showed a small decrease on the total for a month earlier. Reductions in both the number of personnel wholly unemployed and in the numbers of persons temporarily stopped in the building and fishing trades were only partly offset by increases in the metals-manufacturing industry—mainly among employees temporarily disengaged—and in the engineering and textiles industries. The Minister told Mr. Hector Hughes (Labour) that he was closely following the discussions which were taking place at the conference of the Scottish Trades Union Congress at Aberdeen. He had had most interesting and helpful discussions with the Scottish TUC when visiting Scotland recently. He would certainly study whatever recommendations or suggestions they might put forward.

ADVANCED SCIENCE COURSES

The Minister of Education was asked by Mr. Malcolm MacPherson (Labour) how many degree courses in science at technical colleges had been closed down in the last three years. Mr. MacPherson suggested that a number of degree courses at colleges in the London area had, in fact, been discontinued and that a number of other courses were severely under strength so far as the number of students was concerned. At the same time, many sixth-form students were not able to find places in university courses when they left school. Could not the development of degree courses at technical colleges be further encouraged?

Mr. Geoffrey Lloyd replied that there was a misunderstanding. The courses that had been abolished had been closed down mainly because of the lack of students, in accordance with the recommendations of a working party report published last year. Some courses, for example, had had only four members in one year. It did not seem right to continue such courses when similar courses were available in, say, another technical college within easy reach.

NO ROOM AT THE UNIVERSITY

Later, Mr. Malcolm MacPherson asked the Chancellor of the Exchequer about the numbers of men and women who were qualified for entering university degree courses, and who wished to enter upon such studies, but who were unable to obtain places. He considered that the present position was very unsatisfactory and that consideration should be given to the possibility of setting up a clearing arrangement, whereby the numbers of persons waiting to enter courses could be accommodated, at least to the extent that there were places available in universities.

Mr. J. E. S. Simon, the Financial Secretary to the Treasury, said that an inquiry had been commissioned by the Committee of Vice-Chancellors and Principals. The committee's report showed that, judging from a sample of men and women applying for admission to universities in 1955-56, there were possibly between 2,000 and 2,500 persons, who had at least reached the standard required for entering upon degree courses at the University of London, but who had failed to secure admission to any university, then or later.

One way of dealing with the matter was to increase the total number of university places, on the lines of the recent statement by the Chancellor of the Exchequer, when he looked to a university population in the mid 'sixties of 30,000 more than the present figure. The universities themselves were considering what could be done to deal with the difficulties mentioned and how to secure better co-ordination.

WARSHIPS FOR SALE

A number of matters relating to the Royal Navy were raised by Captain H. B. Kerby (Conservative). Among other points, he wished to know what negotiations had taken place for the sale of the aircraft carriers Warrior and Magnificent to South American powers.

Mr. Robert Allan, the Parliamentary and Financial Secretary to the Admiralty, stated that it was not in the public interest to disclose negotiations of this character. The costs incurred in refitting H.M.S. Warrior with an angled flight deck and other modern equipment during her refit at Devonport Dockyard, completed at the end of 1956, amounted to approximately £830,000.

No tank landing craft, Mr. Allan said, had been laid down to replace the existing war-time-constructed vessels of the L.C.T. (8) type. The future of these craft was under consideration and it seemed likely that they would have to make way for vessels of improved design, to meet the changing needs of amphibious warfare.

School Science Laboratories

Asked by Mr. Will Owen (Labour/Co-operative) about the opportunities of sixth-form pupils at grammar schools to study science in school laboratories, Mr. Geoffrey Lloyd, the Minister of Education, said that he was not able to state how many schools lacked adequate science laboratories. Projects costing some £2 million had been included in the 1958-59 building programme for additional science accommodation at grammar and technical schools. He had recently invited local education authorities to submit proposals for further improvements of this kind, so that he could consider their inclusion in the Government's building programme for the financial year 1959-60.

Nuclear Powered Ships

Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, told the House that he had recently invited all the interests in this country concerned with the nuclear propulsion of ships, while at sea or in port, to be represented on a committee formed to advise him on all the various safety problems which are likely to arise. The British Government had also proposed to the contracting Governments of the International Convention for the Safety of Life at Sea that a conference should take place in 1960 at which these problems might be considered. Mr. Watkinson informed Mr. S. S. Awbery (Labour) that the British committee would commence its sittings and begin making its recommendations almost at once.

Staggering of Working Hours

The report of the Committee for the Staggering of Working Hours was published on 2 April. Mr. Watkinson told Mr. E. Partridge (Conservative) that the report showed that the campaign had made a promising start, but that there was still much to be done to convince employers and staffs of the advantages of staggered hours. The system offered the most satisfactory practical solution to the problem of congestion at peak periods and Mr. Watkinson said that, at a meeting which he had had on the previous Monday with the committee and with the chairmen of the zone sub-committees, they had considered how the campaign should be developed. He had assured the committee of his fullest support for its efforts and he hoped that these would have an increasing impact on London travel.

Railway Modernisation

British Railways modernisation plan for making capital improvements had progressed much more quickly than had been originally expected, Mr. Watkinson told Mr. Geoffrey Wilson (Conservative). Important matters of technical and commercial policy had been decided and British Railways were now committed to a large part of these developments. It should be said, however, that the programme was not quite so far ahead as it would have been if he (Mr. Watkinson) had allowed the railways to spend a great deal more money than it would have been in the public interest for them to do in the present financial circumstances.

Large Order for Locomotives

A very large order had recently been placed by British Railways, Mr. Watkinson said, for the new British Deltic locomotives. It was to the acceleration of the railway modernisation plan that the country must look for increased train speeds and greater punctuality. He had been advised that the limitations imposed on capital expenditure by the railways would not invalidate the achievements likely to be made by 1962 as set out in the White Paper on the modernisation plan. The House must judge for itself whether £1,500 million spent on modernisation and £250 million on financing a deficit were not as much as the country could afford from its scarce capital resources.

Atomic Review

FBI Conference on Nuclear Energy

BRITAIN proudly leads the world in the building of nuclear power plant. This country has already embarked on a programme utilising this new source of energy to generate 6,000 MW by 1965, at an estimated cost of £750 million. In addition there is every indication that there will be a substantial overseas market for these reactors and their associated fuel-processing plants. Much of our success to date is due to the way British industry, covering a wide range of activities, has taken advantage of the opportunities provided by the United Kingdom Atomic Energy Authority and, with its co-operation, brought nuclear power to a state when it can compete on economic terms with conventional power.

Groups of firms have combined their specialised experience and resources to form a small number of consortia each capable of undertaking a contract for the building, installation and operation of reactor plant. Each one of these groups may call on 400 or more smaller firms to contribute to such an undertaking. A short-term view over the next five to ten years might suggest the need to limit cut-throat competition between large groups to save a drain on technological resources. A long-term view of a possible growing gap between world power requirements and available supplies of energy from more conventional sources, would however, lead to the more encouraging view that there will be a world wide demand for nuclear power plant far greater than at present could be foreseen, and therefore room for more firms and groups of firms to participate in the market.

Within the relatively short span of two decades the exploitation of nuclear energy has become big business, involving millions of pounds capital expenditure and the material, technical, scientific and engineering resources of many countries on a large scale.

It is fitting that, with the rapid rate of advance of this new technology, stock should be taken of developments in the light of present and future requirements. In this respect the Federation of British Industries, and in particular its director-general, Sir Norman Kipping, J.P., have done a great service to industry in this country by making possible what proved to be a most timely and successful conference. Held in Eastbourne between the 9 and 12 April, it was attended by 100 members of director status, including 25 industrialists from overseas.

Co-operative Effort in Nuclear Power

In his opening address the conference chairman, Sir Claude Gibb, K.B.E., F.R.S. (managing director, C. A. Parsons), referred to the grave shortage of world energy and the opportunities provided for closing the gap with nuclear power. As the conference proceeded the need became more obvious, as Sir Claude said, "to view the possible field of development in proper perspective." One should not be lead astray by the "glamour" at present attached to the word "nuclear." There were grave responsibilities both technical and financial upon those entering this field and the conference provided an opportunity for firms—those already actively participating and the growing numbers still only on the fringe—to share problems, hopes and the dangers of possibly "burning ones fingers." Although at least five large groups of companies or consortia had been thought necessary to provide competitive tendering for nuclear power stations, there was a feeling that excessive competition would jeopardise the whole economic structure of the industry as well as resulting in waste of scientific and technical manpower due to overlapping of programmes. It was pointed out that in building a power station such as Berkeley, Hinkley Point or Bradwell, one of the large groups might call upon as many as 400 firms to contribute and that with future stations the number might be as many as 1,000 firms.

During the conference, tributes were paid to the work of the United Kingdom Atomic Energy Authority and the way it had co-operated with British industry; in particular reference was made to the foresight of men like Sir John Cockcroft, Sir Christopher Hinton and Sir Leonard Owen in determining the most promising lines of development leading to Calder Hall and the first commercial nuclear power stations now being constructed for the Central Electricity Generating Board. No less cordial were the compliments paid by Sir Edwin Plowden, K.C.B., K.B.E. (chairman, UKAEA), and Sir George Thomson, F.R.S. (guest of honour at the conference dinner) to the way British industry had accepted the challenge. The rate of scientific and technical advance in this country had been such that the nuclear power programme outlined in the White Paper of 1955—which envisaged the building of 12 nuclear power stations by 1965, entailing an estimated expenditure of £300 million and providing up to 2,000 MW—had recently been stepped up to provide 5,000 to 6,000 MW by 1965. When the programme was originally planned the generating capacity of an atomic station was estimated as 150 MW; it was now possible to build stations having a capacity of about 500 MW, by using larger reactors.

During the conference attention was drawn to the fact that this did not necessarily mean more scope for competition or room for more contractors since, as had been stated the previous week in the House of Commons, it now seemed likely that the new capacity could be achieved with 14 or fewer stations compared with the 19 originally contemplated.

Prototype Costs

In a delightfully lucid, frank and comprehensive address Sir Edwin Plowden referred to the history and growth of the UKAEA, the tremendous scientific and technical effort required to bring a reactor system to the stage of commercial development and its cost, the special problems involved in determining the type and extent of collaboration with industry, the immediate way ahead and the impact of the reactor programme on industry in general far beyond the realms of nuclear power engineering. These remarks gave the conference an encouraging send-off, for it went a long way to remove any misapprehensions which industry, and especially smaller firms, may have had about the policy of the Authority in its collaboration with industry. Sir Edwin made it quite clear that this country in particular was very much dependent on new supplies of energy other than those obtainable from oil and coal. If we must maintain our position in an expanding economy this country must plan its energy supplies to meet the long-term demands.

The Authority was a nationalised industry, with a difference in that the bulk of its expenditure was voted annually by Parliament. Besides its responsibilities for partnership and collaboration with industry in civil uses, the Authority was responsible for weapons, chemical plants for fissile materials, ensuring uranium supplies, control of radioactive materials, the fundamental nuclear research programme in collaboration with the universities and other research organisations as well as for certain overseas commitments involving negotiations with the United States and OEEC countries.

The extent to which industry was dependent on the Authority was emphasised by Sir Edwin's detailed account of the extensive experimental facilities and the large number of staff to develop and prove a reactor system. Typical figures quoted were: (i) for the initial research and development programme, 1,000 man years by university or comparable staff; (ii) for one year feasibility study and experimental reactor operation, 15 to 100 scientists or engineers; (iii) for one year on reactor design, 100 to 150 engineers; (iv) for two years' reactor study, 200 staff; and (v) the three years required to build a prototype reactor and to carry out reactor control experiments would involve 100 professional staff. Including the necessary support facilities it was estimated that the cost for each professional scientist or engineer employed by the Authority was in the region of £10,000; and that the cost for a prototype reactor might be £10 million.

This was not all, for it did not take into account the cost of the basic investigations involved in exploring the different possible systems: reactor development was not complete with the building of the prototype, for there were still problems of operation and processing the fuel, involving a major programme. In all, the total cost of an effort such as Calder Hall would be nearer £20 million. A more advanced type such as Dounreay would cost more. Moreover, all the systems explored were not successful. It was such considerations which determined why the major responsibility for work up to and including the prototype stage had to be invested in the Authority, since the facilities required were far beyond those which the engineering industries themselves could provide.

To meet the demand for generating plant the Authority had encouraged the formation of, at first four and later, five major consortia of industrial firms, each capable of designing, building and equipping a nuclear station. In addition there had been contracts placed with firms for the solving of special engineering problems, such as those associated with the building of Calder Hall; for instrumentation and control equipment, and with the chemical industry for the design and erection of chemical plant. Later it was intended to bring in other industries to develop different types of reactor systems. In deciding which firms to collaborate with, it was necessary to ensure that they had the facilities and resources to enable them to take full advantage of the ideas passed on to them. The Authority had been responsible for setting up training schools, such as the reactor school and isotopes school, to which could be sent representatives of firms, the electrical boards, and other bodies, as well as students and representatives of countries overseas—the latter being important if we were to secure an export trade in this field.

It was also pointed out that these training schemes imposed an additional burden on the Authority since they involved withdrawing professional staff from research and development work. This and the importance of ensuring the most efficient use of the country's scientific and technical manpower were important factors in determining to what extent industrial firms should be encouraged to participate. It was hoped that in due course the universities and some of the colleges of technology would be able to provide most of the basic training. For these and other reasons the industrial development programme could not proceed independent of the Authority.

Reactor Types

Confidence was expressed throughout the conference in the gas-cooled graphite-moderated system, the practicability of which had been demonstrated to the world by Calder Hall and which had been adapted as the basic design for the nuclear stations now under construction for the Central Electricity Generating Board. This system had already been proved capable of further development, and with advances in the production of fuel elements it became possible to operate the reactor at a higher temperature, thus decreasing the capital costs of building for a given power output and reducing the cost per unit of electricity from nuclear energy.

A comprehensive survey of the various possible reactor systems was made by Dr. D. J. Littler who until recently had been principal of the Reactor School at Harwell. He mentioned possible lines of development with gas-cooled graphite-moderated reactors by using slightly enriched uranium oxide fuel in a beryllium can,

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instead of the magnesium-alloy can at present used, to enable the fuel element to withstand higher operating temperatures; a further development would be to use an all-ceramic fuel element. With slightly enriched uranium the heat rating of the graphite-moderated fuel elements could be increased by using liquid sodium as coolant—although the latter introduces difficulties.

With slightly enriched uranium, ordinary water could be used both as a moderator and coolant. In one such system the water is allowed to boil and drive a turbine or the water is pressurised and the boiling suppressed. The latter system has been given special attention in the United States—the submarine Nautilus and the land-based reactor now operating at Shippingport, being the result. As a variant, an organic liquid, having a higher boiling point than water and stable under neutron bombardment, might be used instead of water as a moderator. With fuel more highly enriched it became possible to consider circulating the fuel itself through a heat-exchanger external to the reactor—the fuel being either a solution of enriched uranium as a chemical compound in water or heavy water, that is, the so-called " homogeneous type," or dissolved in a liquid metal such as bismuth, " liquid metal type." Then there was the Dounreay type of reactor in which highly enriched fuel (highly enriched uranium, plutonium or uranium 233) is used to make a self-sustaining chain reaction without using a moderator. With a fast reactor of this type it is possible, by inserting a fertile material, such as uranium 238 or thorium, which absorbs neutrons and become fissionable material in the process, to make more active material than it burns. One of the problems with this type of reactor is to get the heat away quickly enough from the core; liquid metal cooling has been used at Dounreay.

Discussion at the conference tended to emphasise the economic aspects of the various systems. In the United Kingdom, development had been influenced by having supplies of natural uranium available whereas enrichment involved special plant and was a costly process increasing the fuel costs. On the other hand the United States had adequate supplies of fissile material and this was conducive to the water-moderated type of system which they had developed. Similar considerations lead to the use of graphite as a moderator, but now that heavy water was becoming available at a greatly reduced price, the possibility of using this moderator, with the advantage of a smaller critical reactor size and lower construction capital and fuel costs, was attractive. It was evident from the ensuing discussion that with the present designs of nuclear power stations the greatest economies were to be made by reducing capital costs in relation to power output, since fuel costs were already lower than for coal-fired stations. As an example of this trend, it was now possible to fabricate the pressure vessel for the Hinkley Point power station with 3 in thick steel plate instead of 2 in as used at Calder Hall. This enabled more than half as much again of uranium fuel to be contained in a pressure vessel of the same size. Compared with the United States boiling water reactor, the United Kingdom reactors appeared more economical (a rough estimate of the relative cost of electricity supply per unit being quoted at United States 5·4*d* and United Kingdom 1·25*d*) but, also as important were the facilities which the United Kingdom reactors had to discharge and recharge fuel while on full load, whereas with the pressurised water system it was necessary to shut down the plant for several days to enable this operation to be carried out because of difficulties of access to a pressurised system. Canned fuel elements also have advantages as regards health hazards since the fission products are contained within the cans themselves.

Questions were asked about " packaged " power units but the general feeling was that only in those areas where supplies of fuels such as oil or coal were impossible, would such units be attractive. In units with power outputs of less than 20 to 30 MW, it was not thought they could be made economic. Reference was also made to the use of reactors to supply energy for district heating schemes, as in Sweden. For ship propulsion the opinion was that nuclear power would only be economical for ships of 50,000 tons or more. It was agreed that the United States submarine Nautilus had demonstrated the possibilities, but at a high price, perhaps as high as 2*s*. 6*d*. per unit.

New Metals

Sir Claude Gibb expressed the opinion that new developments in metallurgy rather than those in nuclear and chemical engineering or instrumentation, would probably determine future progress in reactor development. In design considerations there had been a shift in emphasis from engineering to metallurgical problems.

Work on progress within the United Kingdom Atomic Energy Authority to meet the demands for new materials was described in a paper by Mr. L. Grainger, assistant director (metallurgy), research and development. He outlined the special properties required of materials used in reactor systems for canning fuels, for use as moderators and for structural applications. The selection of materials was governed to some extent, as in the chemical engineering industry, by stress conditions in service, operating temperatures and environment. In addition, nuclear applications imposed special considerations such as the behaviour of materials when irradiated and their ability to capture neutrons, so reducing the number available for fission.

To meet the demand for increased efficiency from thermal reactors, by increasing fuel element operating temperatures to 700° C and higher, special attention had been given to the production and fabrication of beryllium and zirconium as canning materials. Powder metallurgy techniques had been successfully applied to beryllium powder, and extrusion and rolling techniques established. Some of the difficulties were associated with welding, lack of ductility in a transverse direction after mechanical working and possible irradiation effects. Zirconium has excellent fabrication characteristics but for use in reactors must be separated from hafnium with which it is associated in the ore. Reactivity with carbon dioxide at moderately high temperatures and loss in strength above 500° C limited the applications of the pure metal. Its good resistance to corrosion in water depended on impurity content, especially the amount of nitrogen present. Corrosion resistance in water at high temperatures was very high if nitrogen content is reduced to 20 p.p.m. Alloyed with up to 5 per cent tin, a useful series of corrosion resistant alloys, known as the " Zircaloy " series, were produced. The greatest potential use of zirconium and its alloys was in water cooled reactors, a typical application being the boiling water reactor for the Nautilus submarine.

The development of refractory metals is essential for the operation of high-temperature liquid-metal cooled reactors such as the experimental Dounreay reactor. Niobium with its high melting point (2,470° C approximately) and other suitable physical and mechanical properties had been selected as a most suitable refractory metal for development. The success of this exercise was indicated by the fact that, by utilising high vacuum or inert atmosphere techniques to prevent the absorption of nitrogen and oxygen, which induce brittleness, it is now possible to produce ductile metal which could be forged, cold-rolled, cupped and drawn into tube, or into wire 0·0002 in dia. It was anticipated that as a result of these developments the demands for these new materials would be as follows: beryllium for canning in gas cooled reactor programme, at least 100 tons per annum; zirconium (hafnium free) for moderate use in gas cooled reactors and increasing use in water cooled reactors, up to 50 tons per annum within the next few years; the use of niobium is at present experimental but likely to grow.

As solid materials for moderators, graphite was likely to remain the main material for thermal reactors. Beryllium was suitable, but the high cost limited its use except in small reactors where it was advantageous in reducing weight and space. There was an extensive demand for a high temperature oxidation resistant pile graphite. Advanced types of gas-cooled graphite-moderated reactors were also likely to give more trouble as regards carbon dioxide reaction. There was also the problem of dealing with growth and stored energy (Wigner) effects, and in the case of liquid coolants, of preventing their penetration into the loose structure of graphite. The possibilities of physically separating the graphite from the coolant or of applying a suitable form of protective coating were being investigated. A technique developed at the Royal Aircraft Establishment, Farnborough, which deposits a layer of high-density graphite on the surface, had shown promise. Structural materials, particularly those subjected to irradiation needed special investigation. Studies are in progress to determine the extent of embrittlement of different steels under these conditions. In this respect high ductility is useful, but at higher operating temperatures the creep properties of such steels may not be satisfactory. Steels with a suitable combination of properties are being developed for pressure vessels designed to operate in the range 400° to 500° C. Alternatively, a double shell might be used with suitable insulation to separate the high temperature and irradiation effects. To withstand the higher temperatures in fast " breeder " reactors it became necessary to use high alloy steels of the stainless or heat-resisting types.

A complementary paper was that presented by Mr. C. Buck (chief engineer, chemical plant design office, UKAEA) on the fabrication and processing of fuel elements. Not only did it still further emphasise the costly and extensive research and development preparatory work necessary to make a nuclear power station programme possible but, as Dr. A. T. Bowden (research director, C. A. Parsons and Company) pointed out, when introducing the speaker, the economics of such plant was tied up with the availability of fuel elements and their processing. In seeking contracts overseas, guarantees on these matters had to be given. It was foreseen that there would be an export market for fuel processing plant and facilities were being provided for the chemical plant industries to train their staff so as to be prepared for overseas demands.

It was estimated that the cost of plant to produce natural uranium fuel elements would be about £200,000 and the plant to process active elements after " burn out " up to £400,000. It was now possible to design continuously operating plant. The initial fuel charge for the reactor of a 150 MW plant would cost £4 to £5 million, the breakdown being two-thirds for ore and ore processing and one-third to produce the fuel element. Mr. Buck's paper described the complete processing cycle for fuel elements, dealing with the purification stages from uranium ore to metal, the fabrication of fuel elements for various types of reactors, the processing of irradiated fuel elements and the subsequent purification processes before refabrication into fuel elements. The processing of uranium was carried out to very high standards of purity and special methods of analytical control had been developed, in order to keep impurities, such as the rare earths, as low as one part per million. At all stages of production of the fuel cans there was inspection to rigorous standards of specified requirements with regard to purity and cleanliness, mechanical strength and ductility, grain size and freedom from flaws, cracks, inclusion and oxide coating. Calder Hall required 10,000 fuel elements; the new reactors under construction would require 20,000. In the first year of operation at Calder Hall it had only been necessary to withdraw three fuel elements because faults had developed and for two of these the trouble could not generally be attributed to manufacturing process. In fuel element design

and production, almost guaranteed reliability must be achieved as the removal of a burst fuel element could be a difficult matter, and the cost of reactor shut down for this operation was very high.

The processing of irradiated fuel elements called for remote handling gear, heavy shielded containers and facilities for separating and handling the highly active materials. The design of such plant involved special maintenance considerations and new methods of plant control and instrumentation. Treatment of the highly active fission products involved not only the separation of uranium and plutonium but pilot plant designed to separate the radioisotopes caesium and strontium, which are being used increasingly in hospitals.

Reactor Instrumentation

The Windscale incident, as Mr. D. D. Walker (managing director, Evershed and Vignoles) chairman of this session, reminded the conference members, had brought home to all responsible for the design, building and operation of nuclear plant the vital necessity for an adequate warning system under emergency conditions. Sir Claude Gibb in his summing up at the end of the conference also referred to the Chalk River accident when the NRX reactor had " run away " with disastrous results both materially and as regards the morale of the people concerned. Nevertheless in the latter case, while before the accident it would have been thought necessary to abandon such a site, perhaps for 5,000 years, it had been proved possible to decontaminate the area and build a new reactor on the same site, ready for operation within 15 months. Important lessons had also been learned from Windscale and one opinion was that in some respects it was fortunate that it had occurred at this stage of the development programme. The cost of instrumentation was given as less than 2 per cent of the total cost of a nuclear power station. Not a high price for safety.

Mr. M. V. Needham (assistant group manager, engineering, Elliott Brothers) in his paper on reactor instrumentation, emphasised the essential role of instrumentation in ensuring the safe operation of a nuclear reactor. The nature and amount of instrumentation involved would depend on the type of reactor and on the purpose for which it was built, but a certain basic complement for control and safety was common to all types. The type of equipment ranged from simple means for temperature measurement to complex instruments for detecting and measuring neutron flux. Electronic techniques as applied to computing, data processing and control engineering were also finding applications. Arising from the earlier pioneer work of the UKAEA, a considerable commercial activity had arisen to meet the requirements of the new power plants.

Investing to Meet World Demands

Two papers presented to the Conference, one " Nuclear Energy and the World's Fuel and Power Requirements," by Mr. E. F. Schumacher (economic adviser, National Coal Board), and another entitled " Financial and Investment Aspects of Nuclear Energy, Including Home and Overseas Markets," jointly by Mr. J. R. Cuthbertson (head of intelligence department, Lazard Brothers and Company, Bankers) and Mr. John Brodrick (head of intelligence department, English Electric Company Limited), provided a useful summary of information which might serve as a guide to economic future planning of nuclear development.

Mr. Cuthbertson and Mr. Brodrick concluded that neither the physical nor the economic hazards associated with the exploitation of nuclear energy, nor the amount of capital required to install a nuclear power plant, raised any entirely new or unusual problems of finance.

The construction costs, however, of an atomic power station were at present twice as high per unit of electricity generated as for conventional thermal plant; and it was not expected in the immediate future to be really competitive, except in locations where the cost of fossil fuels was unusually high and hydro-electric resources were poor or non-existent. The competitiveness of nuclear stations would be extremely sensitive to interest rates, to the distances of potential sites from sources of conventional fuel, and to the extent to which such plants could be operated day and night at maximum outputs. For example, when nuclear plant is operated at only 60 per cent of maximum output, the electricity sent out costs about 40 per cent more per unit than when it is operated at full load, while for conventional plant the corresponding increase is only about 20 per cent. At present United Kingdom power stations are operated on the low average load factor of about 46 per cent.

An optimistic view was taken of the export market (see " Atomic Export Forecast," Marketing, p. 529 of this issue). It was pointed out however, that unless there was a considerable change of Government policy towards the provision of long-term finance for exports, Britain's nuclear power trade would have to be financed mainly by medium-term bank credits.

Mr. Schumacher, in his paper, endeavoured to look ahead, not five but 25 or 50 years, to throw some light on possible future world demands for power assuming a gradual equalisation of living standards throughout the world and comparable with, say, the present American standard—an assumption not accepted by all attending the conference as being likely. It was calculated that under these conditions it would be impossible to sustain such a high standard of development by conventional fuel such as coal, oil, natural gas and water power and it did not seem that even nuclear energy would be able to fill the whole of the gap. Especially serious would be the high rate of consumption of the commercial sources of energy which are preponderantly non-renewable and in general a pessimistic view was taken of the possibility of untapped reserves of these energy resources being able to contribute to the solution of this problem. The survey emphasised that the world stood very much in need of new sources of energy and nuclear energy on a worthwhile scale was most desirable.

He considered that the fundamental problem of Western European economy was and remained that of achieving stabilisation and of developing an economic system that would cease to worship a purely quantitative standard of living and foster instead the quality of life.

One of the heat exchangers being erected at Berkeley.

Notes and News

Heat Exchanger Erected at Berkeley

The first of 16 large heat exchanger vessels for the Berkeley nuclear power station was erected on site on 3 April. Final fabrication of this vessel which is 70 ft long, 17 ft 6 in dia. and weighs 133 tons was completed by John Thompson Limited, the manufacturers in a boiler shop on the site, and transported on two bogies to the place for erection about 300 yd away.

The five cylindrical sections and each of the end sections were fabricated at Wolverhampton from 1⅛ in steel plate, the welding being done on rotating jigs using Union-melt machines. Compensator rings 6 in thick were also welded in position to provide strengthening at the gas ports. All the welded seams to Class I specification were subjected to radiographic inspection using a gantry-mounted 250 kV X-ray set. Stress-relieving of the sections was carried out in an oil-fired annealing furnace. After site welding the sections, the welded joints and adjacent areas were stress-relieved by induction heating, temperature being raised to 600° C at the rate of 178° C per hour, with a cooling period of 1⅛ hours. All ports and sleeve connections for the pipework were then sealed and the vessel hydraulically tested to 240 lb per sq. in.

Lifting was done with the aid of a pair of 5 in poles, carrying tackle powered by two winches, with a 130 ft boom (15 ton) Lima crane operating as a retaining winch at the rear, or base, of the vessel as shown in the illustration. A tail bogie and rocker was provided to allow forward movement of the vessel in the lifting operation.

Plutonium Output in France

It has recently been reported that from early 1959, France will have an output of about 100 kg of plutonium a year and that to make one bomb would require between 10 and 15 kg. At present two new reactors, G2 and G3 are being built in France, primarily for the production of plutonium. These are at Marcoule, near Avignon, and it has been stated that each of these reactors will have an output of 200 MW (thermal).

Radioisotopes in Scientific Research

The proceedings of the first (UNESCO) international conference on radioisotopes in scientific research at which more than 200 papers were read and discussed, are to be published shortly by Pergamon Press, London, New York, Paris, Los Angeles. They will appear in four volumes edited by Professor R. C. Extermann.

We are informed that the first volume (3) will appear this month (April), and is entitled " Research with isotopes in Human and Animal Biology and Medicine." Three further volumes will follow, dealing with research with isotopes in (1) physics and industry, (2) chemistry and geology, and (4) plant biology, respectively.

UKAEA Documents

A useful guide to United Kingdom Atomic Energy Authority documents, edited by J. Roland Smith, may be obtained from the Authority's London Office, 11 Charles II Street, London, S.W.1. This is not a list of references but provides a general description of the form in which the UKAEA scientific and technical information is published and where unclassified documents may be obtained. Details of the serial codes and numbering systems for identifying and classifying the various types of document are also given.

The Human Element

Commuters' Conundrum

Overcrowding on London's public transport services has become so serious that some direct action by the Government may become unavoidable. The Committee for Staggering of Working Hours in Central London have completed a report on their first year's work and it is published by the Ministry of Transport under the title of *Crush Hour Travel in Central London*. They can offer no hope of a solution other than the staggering of working hours. But, they say, many employers are not yet persuaded that staggered hours are practicable. They conclude that " there is no doubt that the time-honoured tendency for all business to start and finish at the same time is the greatest single cause of the transport peaks." Notwithstanding the lack of success of the methods of voluntary staggering by direct approach to individual firms, the Committee want to persevere in their efforts to enlist the help of the business community.

Throughout the report it is emphasised that universal staggering is not necessary. In fact as the Minister of Transport said himself in a message sent out to companies last month " the adjustments being sought are relatively small." They are different for various parts of London which has therefore been divided into six areas for the purposes of the campaign. The success or failure of this appeal is likely to depend largely on the working public's response. This the Committee make clear when they write in conclusion " it may still be possible to halt the progressive aggravation of peak congestion on public transport services by voluntary action, if the public can be persuaded that it is to their advantage to demand and to support the changes needed."

The really frightening message in the Committee's report is that the present " crush " is nothing to what is to come, as a result of the erection of new office buildings.

Monopoly and Redundancy

The decision to ban overtime by a section of the employees of BOAC is a reminder that there is another side to the security of a state monopoly. The pressure of competition has forced the corporation to look for economies in its operations and it has found that its maintenance costs are higher than those of similar operators. In one sense there is cause for satisfaction in that one source of high costs has been found by the pressure of competition. The men who are in consequence redundant and their shop stewards think differently, of course.

The trouble about monopolies (state-run or otherwise) is that economy drives are often infrequent and therefore all the more drastic when they come. The Russian political juggernaut works on this basis. Monopolies breed a cosy sense of security and a good deal of quiet empire building and inter-departmental *amour-propre* which reduce efficiency. If there were more competition all the time and that competition were allowed to make a constant impact on the management structure of any organisation in a monopoly position, then departments would be run more economically. It would all be less comfortable but it would be tougher, leaner and less subject to periodic and violent spring cleaning in which a large number of innocent people got hurt.

Fast Talking

Everyone connected with the railway wage negotiations is trying to give the impression as hard as they can that they are most anxious to avoid a strike. They are keen to go on talking as long as there is any hope of a settlement. The maxim is repeated that talking is better than fighting. The result so far has been to increase the public confidence that a way will be found out of the dispute without anyone giving way—which is something of a contradiction in terms. So far, indeed, there has been remarkably little sign of anyone having changed their bargaining position.

To Sir Brian Robertson's great credit it can be said that he has taken the initiative with a scheme for paying higher wages out of increased productivity—so it is reported, although at the time of going to press not very much was known about the terms which he has offered the unions. The most that has been achieved so far is that the parties have had discussions on the subject with the Government. It is just possible that out of this meeting will come an arrangement which gives something to the railwaymen if they are prepared to be patient without mortgaging the railway modernisation programme. If anything other than something which amounts to a minor piece of accounting jugglery takes place, the Government will in effect have climbed down and will have to take the consequences on other outstanding pay claims. Altogether there is little ground for optimism on the part of the public unless it is prepared to build on such an insubstantial moonbeam as a ray of hope.

Unity Through the Guild

The Engineers' Guild was formed to ensure the future welfare of the profession and to safeguard the interests of professional engineers just as the British Medical Association, or the Royal Institute of British Architects, are organised to do battle on behalf of doctors or architects. The vital difference between them and the Guild lies in the degree of support they receive. The BMA's membership is between 80 and 90 per cent of all the medical profession: the Guild have some 8,000 out of a possible 100,000 engineers who are members of the Institutions. For this reason the Guild cannot get full recognition as a body representing professional engineers; even if it did it could not wield the influence required to carry out its functions.

Clearly some action is required to clarify the situation and to secure the support which would hardly be withheld if the functions of the Guild, and the need for these, were understood by the members of the Institutions. The Guild is beginning to take such action by advertising in the May issues of the journals of the Civils, the Mechanicals and the Electricals, putting the facts of the case. An outspoken leading article in the *Journal* of the Guild states the position quite plainly, and puts forward the arguments in favour of a central body. This is the start of a drive to reach professional engineers and to secure their support, in their own wider interests as engineers and employees. The least members can do is, as the last sentence of the leader states, " to take a fresh look at the Guild and what it is trying to do."

Better than Circulars

Volumes have been written and endless speeches made about the need to increase the number of professional people. Complicated schemes are prepared to show how they are to be recruited, trained and given the right kind of job which will ensure that they are not square pegs in round holes and that they justify the investment which the community is going to make in them. All this is because technical personnel of all kinds is scarce.

One of the consequences of that scarceness is that their price goes up and this is a thought which people find difficult to accept. If one argues that full employment since the war has meant higher wages in industry, one is told that such things are so obvious that they need no repetition. But tell someone that full employment for the professions must have the same effect upon their price and eyebrows go up. The latest occasion has been in the evidence given by Government departments to the Royal Commission on Doctors' and Dentists' Remuneration. The drift of that evidence is that if the pay in these professions is raised too high there will be repercussions on other professional salary and earnings levels. Indeed there will. That is the surest way in the end to get the necessary number of people into the professions. It is going to be much more effective than the thousand and one brochures and pamphlets on higher education which are at present circulating solemnly round the educational system and beyond.

Taking up the Slack

After six years of unbroken boom in the shipyards of the North-east Coast there have been pay-offs in ship-repairing yards and an increase in short-time working in associated industries. With the possibility of heavy cancellation of shipbuilding orders very much in mind, the Tyne and Blyth District of the Confederation of Shipbuilding and Engineering Unions have revived their Full Employment Committee to watch developments in the area. Their task will be to initiate action through M.P.'s, the Regional Board for Industry or the companies themselves to bring fresh work into the district should the situation deteriorate. At the middle of last month some 1,200 shipyard workers were unemployed, the highest figure for over three years. The trade unions are again becoming active in their search for compensation agreements in the event of heavy redundancies.

Not all unions are likely to be in favour of such a move. Craft unions in particular fear that it might encourage companies to dismiss workers as a cheaper way of getting out of trouble. They favour the well-tried work-sharing measures such as overtime bonus, short-time working and reduction of subcontracting. Employers tend to favour industry-wide agreements, negotiated between the Engineering and Allied Employers' National Federation and the Confederation of Shipbuilding and Engineering Unions. None the less, several agreements have been signed by companies in recent months, notably Chloride Electrical Storage, Tube Investments, Ford Motor, and, more recently, Yorkshire Imperial Metals. Negotiations are proceeding with several other large companies and it may be that this method will win favour from both sides.

Relief Through the Banks

The Government's help to areas of high unemployment is going to take the form of relaxing credit restriction in the areas concerned. The Government's policy will therefore be implemented through the banks and the Capital Issues Committee. In his Budget speech, the Chancellor said that it would not be Government's wish that " any projects for sound development ' in such areas ' to be held back by lack of credit or finance."

This is a novel way of tackling regional unemployment. It could act much more quickly than the more traditional measures used to promote the growth of industry in development areas, such as the financing of factory construction. Immediate credit facilities can be granted to finance operations on an increased scale, particularly expenditure on sales promotion and operating expenditure generally. A Bill is to be published shortly amending the Distribution of Industry Act, 1945, to enable the Government to provide financial assistance in many areas of severe unemployment (at present it is restricted to those parts of the United Kingdom scheduled as Development Areas under the Act).

Marketing

ATOMIC EXPORT FORECAST

Britain's early start in the development of nuclear power plant is expected to yield handsome dividends in export markets. Two specialists in business forecasting, Mr. J. R. Cuthbertson of Lazard Brothers and Mr. J. Broderick of English Electric, foresee an average annual export of between £60 million and £65 million in the years 1961-65, and between £85 million and £100 million a year in the subsequent ten years. Between now and 1960 the average annual value of export orders is likely to be between £13 million and £18 million. These estimates were given in a joint address to the Federation of British Industries Conference on Nuclear Energy at Eastbourne.

Continental Europe, they considered, was the first likely source of orders, with eight to ten power station projects during the next three years. These power stations were unlikely to be large, for a variety of reasons: most of them would be the first of a series and therefore experimental in character from the point of view of the country concerned; a number of them may be of the pressurised self-refuelling reactor type and it is generally easier to find suitable sites than in Britain, thus permitting a relatively large number of small stations. The first ten are not expected to average more than 150 MW each. Britain's share of these orders is likely to amount to some 35 per cent of the total contract, the rest (including civil engineering) being handled locally. The value of the British exports over the three years was estimated at between £40 million and £55 million. If we supplied the uranium fuel, however, these sums would be raised to between £70 million and £95 million. In addition, export orders from other sources were expected to amount to 500 to 800 MW over this period, providing British industry with about 1,700 MW of capacity to supply. This, the authors said, "was just about equivalent to the capacity of the United Kingdom nuclear power station construction companies to build plants for export, which was usually put at two stations a year of about 180 to 200 MW and was unlikely to exceed three stations a year."

After 1960 the pattern of demand was likely to change; the export income would be then derived principally from royalties and design fees and from specialised equipment such as fuel charging or discharging machines and reactor furnace control equipment. More and more of the "hardware" would be made locally. During the years 1961-65 the demand outside Europe would grow and Britain should secure orders from the Commonwealth and North America. The authors estimated that export demand from these two sources was likely to total 3,000 MW over the 5 years, giving a demand potential of £75 million a year, of which Britain could be expected to get £30 million. European export orders were expected to swell this to £65 million a year.

Undeterred by occupational hazards of looking far ahead, the authors went on to foresee a vast increase in demand in the decade 1966 to 1975 in the great industrial centres of the world in Europe and North America, followed by a demand from Asia, Africa and Latin America. There would be more competition—from the United States, Germany, France, and possibly also from Soviet Russia—but British industry would get its share. This share was unlikely to be less than 1,500 MW of capacity a year, worth about £85 million exclusive of uranium fuel supplies.

This is a very encouraging prospect, particularly for those firms who had begun to despair of obtaining useful orders for nuclear plant. The authors' suggestion that British output over the next 18 years is more likely to be restricted by capacity than by orders is in line with recent statements of the leaders in the electrical engineering industry, but contrary to the expectations of many firms. It is the kind of development which can be expected to take place in a radically new field; a very slow start followed by a period of rapid growth.

Record Exports to North America

Despite the recession in North America, British exports to the United States and Canada continue to increase. In March we shipped £23 million worth of manufactured products to the United States, which was £200,000 higher than the previous highest level established in February. For the first quarter of the year they were 8 per cent higher than the corresponding period in 1957. Exports to Canada for the same period were 4 per cent higher and amounted to £16 million in March.

This performance, so clearly against the general trend of industrial activity in both countries, is most encouraging. It is difficult to explain, though lower prices must play a part; in the case of motor cars, which were so well received at the recent motor show in New York, a change in public taste was doubtless an important factor. Another is probably the much more aggressive sales methods employed by British exporters whose knowledge and experience of the North American market has grown remarkably in the past year or so. All this promises well for the future. It remains to be seen how far the lobbying of United States concerns for increased protection (a specific case is discussed in another note) will influence the course of events over the next few months. It is clearly in the wider interests of the United States economy that imports should continue to increase.

"Buy American"

The United States General Electric Company are calling for increased restrictions on the import of heavy electrical equipment which they claim "threatens the national security." The main basis for their claim is fundamental to all imports of complex plant and machinery: the long delivery time for foreign equipment and the lack of repair facilities in the United States could be dangerous in the event of changes in the international situation. Another is that United States equipment is more reliable. They want a tightening of the Buy American Act, giving domestic suppliers preference in bids, even if these are 6 per cent higher than foreign bids.

The evidence on which these arguments rest is pretty flimsy. Most of the leading British suppliers of heavy plant to the United States, such as English Electric, British General Electric, Ferranti, and others, are in a position to maintain, repair and deliver parts as quickly and effectively as any American firm. The growth of fast air transport completely undermines G.E.'s claim. On reliability there is no case and few would believe their allegations. On price the United States companies' position is poor and likely to deteriorate. Nor is there any reason for the Americans to state a case: in 1956 imports were 9 million dol, exports 90 million dol, and U.S. domestic sales 2,000 million dol.

Tied by Our Debts

Britain will have to go on being a banker to the Sterling area. Only by repudiating her obligations, most of them to countries poorer than herself, could she cease to do so. In mid-1957 Britain's liabilities totalled £4,150 million, while reserves were only £1,350 million. Any immediate repayment of "depositors" is quite impossible and there is therefore little alternative to carrying on.

The whole position of the United Kingdom as a world banker is reviewed in a broadsheet *The Debate on Sterling*, published by PEP (2*s.* 6*d.*). The debate has centred on four main issues: the contribution our position as banker makes to the vulnerability of our economy to external confidence; the possibility of narrowing the gap between assets and liabilities (by increasing the former or narrowing the latter); the need to export more capital, which may well be "the crucial economic factor under-pinning the Commonwealth political unity"; and the need to maintain stable exchange rates to keep trade flowing. The discussion of these points is informative and helps to explain the broad movements of trade which affect engineering so vitally at the present time.

New Zealand's Troubles

Few countries have been hit as hard as New Zealand by the world recession. The price of "New Zealand Finest" butter quoted in the London Provisions Exchange fell from nearly 400*s.* a cwt. in January to about 200*s.* a cwt. in mid-April. A balance of payments crisis has developed and is getting worse. A fall exceeding £50 million in export receipts is estimated for this year and overseas currency reserves are dangerously low (less than £50 million). Unless a substantial loan is secured quickly it will be impossible to maintain imports even at their present low level.

Negotiations are at present in progress with the United Kingdom Government on agricultural problems but it is unlikely that so-called dumping, of butter particularly, by West European countries, can easily be stopped. Any measures leading to a rise in food prices will need a great deal of courage on the Government's part, even with the backing of the Economic Council of the T.U.C., who have asked their General Council to press for anti-dumping measures to help New Zealand. A more likely course of relief lies in the granting of facilities for the raising of a loan of £20 million to £25 million on the London market. The course of events in New Zealand is a good indication of the grim prospects that lie ahead unless commodity prices start to rise again in the very near future.

A Fine Publication

The story of their growth and development just published by Engelhard Industries of Newark, New Jersey, makes fascinating reading for the expert and layman alike. It is an excellent example of good writing and presentation of technical topics. The general effect of the text and illustrations is pleasing and stimulating. But quite apart from this, the story is a good one. It is written round the introductory sentence "an industrial group fostering progress in industry . . ." and contains a lot about catalysts and precious metals in manufacturing processes.

The base on which the entire industrial structure of the group has been built is the manufacture and processing of precious metals. They have developed a wide variety of products, ranging from platinum and other catalysts for use mainly in the processing of petroleum products, heavy water and chemicals to spinnerettes for man-made textile production and electrical contacts, materials and components. They are concerned with the development of scientific equipment, have developed a process for the control of marine corrosion, are deeply involved in graphic reproduction and are beginning to acquire an important stake in the paper manufacturing industry. They have ten companies operating in the United States, one each in Britain, Canada, Switzerland, Colombia, Italy and South Africa and two in Australia. Their new publication has a style in keeping with a group of these wide international ramifications.

Special Article

THE SEA CAN MEET THE WORLD'S INCREASING WATER DEMANDS

New High-Efficiency Distillation Plant

By R. S. Silver
*D.Sc., M.I.Mech.E.**

New developments in the design of plant for evaporating sea water have reduced the cost of water supplied by this means to a level which is competitive with the cost from conventional rain-water sources. Even in Great Britain, which is by no means deficient in rainfall, the increasing demand for water, particularly in large industrial areas, may be satisfied economically by sea-water distillation plants of the type described, if there is a suitable source of waste heat, or if the generation of electricity can be combined with the distillation process.

The production of fresh water for domestic and industrial use is normally a distillation process in which the major steps of evaporation, transport of vapour and condensation are carried out by the sun, the winds and the mountains. Man's activities are concerned only with the final stages of collection, storage, and distribution. The running cost of the fresh water is, therefore, normally the cost of the capital charges on the construction of reservoir and distribution schemes and the costs of operation and maintenance. There is no fuel cost, and no cost for evaporation, vapour handling, or condensation. When, however, we seek to do the whole of the distillation process, these costs are inevitably included.

It does not, however, follow that the costs of an evaporation scheme are higher than those of a precipitation catchment scheme. The relative costs depend clearly on demand and site conditions. In the extreme case of a slow-moving site such as a ship, the catchment costs are those of storage, restriction of voyage due to the need for harbour calls for fresh water, and, in general, such severe limitation that evaporation is not only cheaper but imperative. With a high-speed moving site such as an aircraft the short voyage time makes storage of port-collected water the cheaper alternative. For fixed sites on land, the cost of a catchment scheme depends primarily on the distance from precipitation zones and on the natural contours of the district. If these happen to be convenient for reservoir construction with a reasonable head, costs can be low. If they are unsuitable and if, in addition, there is no reasonably near precipitation zone, catchment-scheme costs are prohibitive. Hence, schemes of fresh-water supply by evaporation of sea water have developed in the last 20 years. They are of obvious primary importance in the development of any coastal or island site where local rainfall is low and land is relatively flat. These evaporation schemes are, therefore, of vital interest in the development of industry and of the tourist trade in such locations. But what is not so obvious is that with modern developments in evaporation-plant design it may well be that the costs of fresh-water supply by evaporation may become competitive with catchment schemes in established industrial countries.

An important factor in this is that if these countries are situated in Europe, for example, the easy catchment areas were exploited long ago, and the cost of new catchment schemes is rising very rapidly. Moreover, the sheer demand for fresh water is augmenting so quickly with higher standards of living and increased industrial demand that the requirements for new catchment schemes involve massive civil engineering work. At the same time operating and maintenance costs are mounting. Even in Great Britain, which is by no means deficient in rainfall, the current costs of water from catchment schemes are of the order 1*s.* 6*d.* to 2*s.* per thousand gallons. These are for the greater part based on old schemes for which the capital cost was very much less than would be the equivalent nowadays. It seems likely that unless local circumstances are exceptionally favourable, any new major catchment scheme will imply a water cost of the order 3*s.* to 4*s.* per thousand gallons. The process described in this article shows how water supply by sea-water distillation may now be obtained at costs of the same order.

RESEARCH AND EXPERIENCE

In recent years, G. and J. Weir Limited have been intensifying their research and development work on large-capacity evaporation plant for land use. In these studies they have had the incomparable advantage of being the largest suppliers of sea-water evaporating plant in the world. Apart altogether from their marine evaporators they have designed and supplied land evaporation sea-water to fresh-water schemes for more than 8 million gallons a day, i.e., about three-quarters of the world's total production by distillation. The massive experience gained in the operation of these plants is unique to this firm and has enabled a completely realistic assessment of the problems to be encountered in any new venture. With this background, the fact that the firm have recently announced a completely new design of evaporation plant and process is of great technical interest. Up till now, all the plants supplied by the company have been of the multiple-effect submerged-tube type. In these the steam or vapour passes inside the heating tubes and the brine is boiled outside the tubes. Vapour from one effect becomes the heating steam for the next effect.

Some 25 years ago, the firm began investigating an alternative evaporation process in which the brine was passed inside the heating tubes without being allowed to boil, and vapour condensed on the outside to give the heat. After heating, the brine was reduced in pressure so that some of the liquid flashed into vapour. The flashing could be staged in a way analogous to the multiple-effect process.

These early investigations showed that the process of heating without boiling did not stop scale formation, which is one of the main practical difficulties in evaporation plant design. Moreover the use of sprays to feed in the brine for flashing causes a risk of serious carry-over, giving impure water. Finally when the number of stages is the same as the number of effects in a multiple-effect submerged-tube plant, the heating surface required in the flash plant exceeds that in the submerged-tube plant owing to poorer end-temperature difference in the heat exchangers. These three factors meant that flash evaporators were less reliable and more costly than submerged-tube plant. It was, however, realised that, provided these problems could be solved, the flash-evaporation principle would have advantages and for this reason research and development work has continued. The firm's submerged-tube evaporation plants include interstage feed heaters in which the brine goes through tubes under conditions similar to those in a flash plant. There was therefore available, in addition to research and development tests, a wealth of relevant practical experience on scale and corrosion problems in brine-through-tube conditions.

For these reasons the firm's new Multiflash process represents a culmination and combination of extensive experience and intensive research. One of the most interesting features in it is the fact that it is possible to work to steam economies which were hitherto prohibitively expensive in capital cost. The only existing major flash evaporation scheme has a performance ratio of about 3, i.e. 3 lb of distillate per lb of steam used. Against that, performance ratios of 8 and upwards are quite possible with the Weir Multiflash process—using less heating surface than was previously required for a ratio of 6 with submerged-tube design.

The conclusion that a flash system could require less heating surface than a submerged-tube system was derived by the writer in a thermodynamic analysis. It was shown that, as distinct from submerged-tube systems where the performance ratio and number of effects necessarily increase together, in a flash system the number of stages may be continually increased without affecting the performance ratio. What is affected is the end-temperature difference in the heat exchangers, which, for a given performance ratio, is continually improved as the number of stages is increased. The tremendous importance of this fact will be realised from the following figures. In a design for given conditions using four stages to obtain a performance ratio of 3, the heating surface required was 0·138 sq. ft per lb/hr of distillate. If 8 stages are used, keeping the same performance ratio, the surface needed is only 0·117 sq. ft per lb/hr, and with 20 stages 0·1 sq. ft per lb/hr. Thus a saving of 38 per cent in the heating surface is possible by multiplying up the number of stages sufficiently. Although this requires some extra steelwork for the greater number of divisions, the cost is far outweighed by the saving in the high-cost tube material. The benefits are proportionately greater at higher performance ratios as the

Fluid at emergence from flow passages, giving a mass of finely-divided bubbles with relatively little break-up but yet presenting a large surface for vapour flashing.

* General manager, technical division, G. and J. Weir, Ltd., Cathcart, Glasgow. S.4.

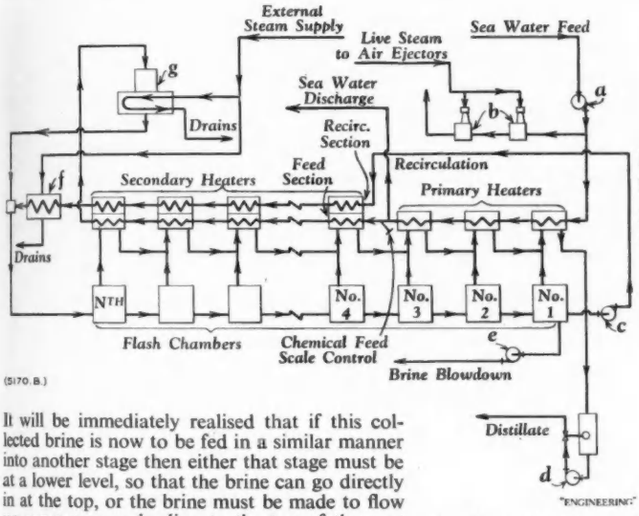
figures in the Table show:

Performance ratio	6		8	
No. of stages	8	20	10	20
Heating surface, sq. ft per lb/hr	0·346	0·224	0·501	0·318

INTERSTAGE PASSAGE DESIGN GIVES LOW CARRY-OVER

A second novel feature of the new Multiflash process also arises indirectly from the use of a large number of stages. The total temperature drop is now split into a large number of successive drops so that the pressure drop from any one stage to the next is small. This means that there is no necessity, as in other flash processes, to absorb large pressure drops by restrictions such as sprays. Equally, however, it presents the problem of providing adequate interface surface from which the flashing vapour can evaporate. As mentioned previously, when this is done by sprays the risk of carry-over causing impure water is great. When sprays are absent some other method must be devised to ensure sufficient interface surface for flashing to take place.

The problem has been solved in a very interesting manner in the Multiflash-plant design. The brine is made to enter the flash chamber near the top and to fall down substantially in a sheet, which may be caught on a tray and cascaded again in sheet form on to another tray or on to collected brine in the bottom of the chamber.



Flow diagram of Weir Multiflash evaporating plant for producing fresh water from sea water.

a. Sea-water feed pump.
b. Air ejectors.
c. Recirculation pump.
d. Distillate pump.
e. Brine pump.
f. External steam heater.
g. De-aerating heater.

It will be immediately realised that if this collected brine is now to be fed in a similar manner into another stage then either that stage must be at a lower level, so that the brine can go directly in at the top, or the brine must be made to flow up some passage leading to the top of the next chamber if it is on the same level as the preceding chamber. For constructional reasons it is clearly desirable to have the flash chambers all on the same level. Since the pressure drop between successive stages is small, the static head difference does not give very great lift of the brine from one chamber to another.

A complete solution to the problem has been found by designing the flow passage from one stage to another in such a way that vapour will commence to flash when the brine starts ascending in the duct leading from the base of one flash chamber to the upper region of the next. The formation of vapour by flashing allows sufficient density difference to secure a substantial addition to the height. The design of these flow passages represents an interesting application of the theory of flow of saturated water and vapour mixtures.*

The resultant flow at the exit of the passages gives a mass of finely-divided bubbles with relatively little break-up but yet presenting a large surface for vapour flashing. The photograph opposite shows the fluid on emergence from the passage.

The remaining points of technical interest in this new process are those concerned with reducing scale and with minimising corrosion. The methods used will be most clearly understood with reference to the typical flow diagram of the plant. In this particular diagram the sea-water feed to the plant, combined with surplus cooling sea water, flows through the first three heat exchangers. The surplus cooling water is then rejected and chemical treatment for the reduction or prevention of scale formation is injected to the feed at this point. The feed then passes through sections of all the other heat exchangers. At the exit from the last it has reached a temperature which is sufficiently high to give good thermal economy but low enough, when combined with the appropriate chemical treatment, to ensure that the rate of scale formation in these heater sections is very low.

The feed then passes to a submerged-tube heated vessel into which it is sprayed. In this vessel it is de-aerated and also a large portion of the potentially scale-forming release of CO_2 takes place, together with the precipitation of sludge. The steam supply to the submerged tubes of this de-aerator represents one source of external heat supply to the plant. When the feed leaves this vessel it mixes with the recirculation, which has been brought up to an appropriate temperature by passing through the main heater sections as shown, and also through a heater supplied with external steam—the other source of external heat supply to the plant. The mixed feed and recirculation now flows to the flash chambers, where the repetitive flash process takes place. The condensation of the flashed fraction in each stage provides the preheat for the feed and recirculation. After the end flash chamber, blow-down to maintain the desired concentration occurs, and the remainder is recirculated.

It will be understood that with this process the brine passing to the flash chambers is de-aerated and the CO_2 content is substantially reduced, thus minimising very considerably the possibilities of corrosion. The main heater-section tubes are fed with this recirculated brine and scale formation is retarded both by the previous scrubbing and precipitation from the feed and by the low concentration and high pressure of the recirculated brine.

Another very important feature of the introduction of a sea-water de-aeration and precipitation vessel in the new process is the improvement of heat transfer rates in the vapour phase in the heat exchangers, due to the elimination of the release of dissolved gas in the flash chambers.

COSTS OF FRESH WATER

On account of the various features which have been described, this design of plant can give very high rates of fresh-water production, per unit of heat input, for much lower capital cost than was previously possible. It is not feasible to give representative figures because these depend so much on the local circumstances in any proposed site. The cost of fuel, the cost of labour and the rates at which interest is chargeable on the capital involved in the plant are the principal factors determining the cost per thousand gallons. It can, however, be quite definitely stated that in certain circumstances the cost is now comparable with and may be cheaper than the cost of water by catchment schemes.

One very important feature affecting the cost is whether waste heat is available from other processes or whether electrical power can be produced in association with the water scheme. An interesting example of the latter is to consider the simple case of using a back-pressure turbo-alternating set instead of a vacuum condensing set. In such circumstances the new plant can be designed to produce more than 14 gallons of fresh water along with every electricity unit produced. Thus a set for 1,000 kW can give over 300,000 gallons of fresh water a day. The running costs of the combined plant have to be covered by the sale of the combined product of electricity and fresh water.

It follows that 1*d.* increase in the price of an electricity unit can reduce the price of the water by 1/14th of 1*d.* per gallon, i.e. by 6*s.* per thousand gallons. Clearly, the relative distribution of the price will depend on the competitive sources of electricity and water.

The competitive source of electricity can be represented by a vacuum condensing plant which would normally produce about 1·5 units for the same cost as the back-pressure will produce one unit. This means that if the electricity produced in the combined plant is to be sold at the competitive electricity rate, then 14 gallons of water have to be sold for a third of the price of an electricity unit. Owing to the extra capital charges involved in the evaporating plant, this is not quite true. Depending on interest rates, the factor may be increased from the above theoretical figure of a third to about half to two-thirds. Taking the higher value and taking electricity produced by vacuum condensing plant at 1*d.* per unit, 14 gallons of fresh water will have to be sold for two-thirds of a penny, i.e. 4*s.* per thousand gallons. It will be seen that this figure is approaching that of modern catchment schemes.

Conversely, in areas where catchment-water costs are high, the sale of fresh water produced in a combined plant can reduce the price of electricity. In the above example, if the competitive price of water was 6*s.* per thousand gallons and the evaporating plant product was sold at this rate, there would be a surplus of 2*s.* per thousand gallons, which would enable the price of electricity to be reduced by one-third of a penny per unit.

It will be understood that this discussion of a back-pressure turbine is only one example to illustrate the scope of the combined electricity and water schemes. Still further reduction in cost is possible when a pass-out turbine using bled steam for supply to the evaporator plant is used. In this connection, the possibilities of combined distillation and electricity production in nuclear power-plant development are very important. In relation to the high capital cost involved in nuclear power, the evaporator capital cost represents a much smaller proportion than with conventional fuel, and the overall situation is that the heat utilisation for a given capital cost is very much increased.

The relevance of this work to water-supply problems can be summarised as follows. The supply of fresh water by distillation of sea water is now reaching a cost level at which it may be competitive with catchment schemes, particularly where it can be combined with electricity generation. On account of the interaction, it would seem desirable that, in the future, any major proposed electricity undertaking near a coast site should be examined with some care to acertain whether it might also be able to contribute substantially and economically to water supply.

* See R. S. Silver and J. A. Mitchell, *Trans. N.E. Coast Inst. Eng. and Shipb.*, vol. 62, 1945, p. 51.

EXHIBITIONS AND CONFERENCES

This list, in chronological order, appears in the last issue of each month. Events noticed for the first time and alterations of dates, places, etc., are indicated by an asterisk (*). For details of events not included below, reference should be made to ENGINEERING, *28 February, page 277, and 28 March, page 406. Organisers are invited to send particulars of coming events to the Editor.*

A.S.T.E. Tool Show.—Thurs., 1 May, to Thurs., 8 May, at the Convention Centre, Philadelphia. Organised by the American Society of Tool Engineers, 10700 Puritan Avenue, Detroit 38, Michigan, U.S.A.

British Columbia International Trade Fair.—Thurs., 1 May, to Sat., 10 May, at Exhibition Park, Vancouver, B.C., Canada. Organised by the Department of Industrial Development, Trade and Commerce, Victoria, B.C., Canada. *Representative:* Agent General for British Columbia, 1 Regent Street, London, S.W.1. Tel. WHItehall 6857.

Agricultural Machinery and Equipment Exhibition, 38th International.—Sun., 4 May, to Sun., 11 May, at the "Plaine de Manoeuvres," Etterbeek, Brussels. Organised by the Société de Mécanique et d'Industrie Agricoles, 29 Rue de Spa, Brussels 4.

Hospital Equipment and Medical Services Exhibition, International.—Mon., 5 May, to Sat., 10 May, at Olympia, London, W.14. Organised by Contemporary Exhibitions Ltd., 40 Gerrard Street, London, W.1. Tel. GERrard 4951.

Prestressed Concrete, International Congress.—Mon., 5 May, to Sat., 10 May, in Berlin. Organised by the Fédération Internationale de la Précontrainte, Paris. Apply to Mr. P. Gooding, c/o the Cement and Concrete Association, Terminal House, 52 Grosvenor Gardens, London, S.W.1. Tel. BELgravia 6661.

Designing Equipment for Human Use, Course on.—Mon., 5 May, to Fri., 16 May, at Engineers' House, The Promenade, Clifton Down, Bristol, 8. Tuition fee £40, excluding accommodation. Apply to the Engineering and Allied Employers' West of England Association at that address. Tel. Bristol 2-5078.

Yorkshire Ideal Homes and Food Exhibition.—Tues., 6 May, to Sat., 17 May, at Leeds. Organised by Modern Exhibition Services Ltd., Manchester House, Burnley Road (Luddendenfoot), Halifax.

***Statistical Sampling in Industry.**—Wed., 7 May, at the College of Technology, Birmingham. Organised by the Royal Statistical Society, 21 Bentinck Street, London, W.1. (Tel. WELbeck 7638.) Apply to Mr. D. Goldberg, Lamp and Lighting Co., Ltd., Melton Road, Leicester.

***Iron and Steel Institute, Annual General Meeting.**—Wed. and Thurs., 7 and 8 May, at the offices of the Institute. Organised by the Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1. Tel. SLOane 0061.

United States World Trade Fair, Second.—Wed., 7 May, to Sat., 17 May, at the New York Coliseum, New York, U.S.A. Managers: The Charles Snitow Organisation, Inc., 331 Madison Avenue, New York 17. Information may be obtained from the British Commonwealth Chamber of Commerce in the United States, 677 Fifth Avenue, New York 22. The fair's British and Commonwealth office is at 36-38 Southampton Street, London, W.C.2. Tel. TEMple Bar 8947.

Mechanical Handling Exhibition and Convention.—Wed., 7 May, to Sat., 17 May, at Earl's Court, London, S.W.5. Organised by *Mechanical Handling*, Dorset House, Stamford Street, London, S.E.1. Tel. WATerloo 3333.

Editors, International Congress of.—Thurs., 8 May, to Wed., 14 May, in Belgium. Organised by the International Federation of Editors, 36 Rue Vivienne, Paris 2e.

Association of Supervising Electrical Engineers, 1958 Conference.—Fri., 9 May, to Sun., 11 May, at the Queen's Hotel, Hastings. Association's headquarters: 23 Bloomsbury Square, London, W.C.1. Tel. LANgham 5927.

***Cotton Board Spring Conference.**—Fri., 9 May, to Sun., 11 May, at Blackpool. Board's offices: Royal Exchange (6th floor), Manchester. Tel. Blackfriars 2573.

ILLUMINATING ENGINEERS

Illuminating Engineering Society, Summer Meeting.—Sun., 11 May, to Wed., 14 May, at Eastbourne. Display of lighting equipment at the Grand Hotel, Eastbourne, on 11 May. Organised by the Society, 32 Victoria Street, London, S.W.1. Tel. ABBey 5215.

***Guided Missiles Conference.**—Mon., 12 May, to Wed., 14 May, at Chase Hotel and McDonnell Aircraft works, St. Louis, Mo., U.S.A. This is the 1958 National Midwestern Meeting of the Institute of Aeronautical Sciences. Attendance restricted to certain U.S. citizens. Institute's offices: 2 East 64th Street, New York 21, U.S.A.

Business Efficiency Exhibition, 168th Regional.—Mon., 12 May, to Fri., 16 May, at the Ice Stadium, Nottingham. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate Hill, London, E.C.4. Tel. CENtral 7771.

International Gas Union, General Meeting.—Mon., 12 May, to Sat., 17 May, at Karlovy Vary, Czechoslovakia. Address of Union: 4 Avenue Palmerston, Brussels.

Production Exhibition.—Mon., 12 May, to Wed., 21 May, at Olympia, London, W.14. Organised by the Institution of Production Engineers. Apply to exhibition offices: 32 Millbank, London, S.W.1. Tel. TATe Gallery 8134.

Gauge and Tool Exhibition.—Monday, 12 May, to Wed., 21 May, at Olympia, London, W.14. Organised by the Gauge and Tool Makers' Association, Standbrook House, 2-5 Old Bond Street, London, W.1. Tel. HYDe Park 3451.

Institute of British Foundrymen, 55th Annual Conference.—Tues., 13 May, to Fri., 16 May, at Buxton. Organised by the Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. Tel. Blackfriars 6178.

***Incorporated Plant Engineers, 11th Annual Conference.**—Wed., 14 May, to Fri., 16 May, at the Grand Hotel, Brighton. Theme: "The Exploitation of Chance." Institution's offices: 12 The Parade, Solihull, Warwickshire. Tel. Solihull 1111.

German Handicrafts and Trade Fair, 10th.—Thurs., 15 May, to Mon., 26 May, at Munich. *Offices:* Theresienhöhe 14, Munich 12, Germany. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

Metallurgical and Engineering Aspects of Weight Saving in Steel Structures, All-Day Conference.—Fri., 16 May, in Glasgow. Organised by the West of Scotland Iron and Steel Institute, 39 Elmbank Crescent, Glasgow, C.2. Tel. CENtral 5181.

1958 British Electrical Conference.—Fri. and Sat., 16 and 17 May, in Brussels. Supported by the British Electrical and Allied Manufacturers' Assoc.; British Radio Equipment Manufacturers' Assoc.; Cable Makers' Assoc.; Electric Light Fittings Assoc.; Radio Communication and Electronic Engineering Assoc.; Telecommunication Engineering and Manufacturing Assoc.; and Water-Tube Boilermakers' Assoc. Apply to the Conference offices: 36 Kingsway, London, W.C.2. Tel. HOLborn 0502.

Castings Congress and Foundry Show.—Mon., 19 May, to Fri., 23 May, in the Public Auditorium, Cleveland, Ohio. Organised by the American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill., U.S.A.

OCCUPATIONAL ACCIDENTS

***Prevention of Occupational Accidents, Second World Congress on.**—Mon., 19 May, to Sat., 24 May, at Brussels, Belgium. Offices: 29 Avenue André Drouart, Auderghem-Brussels, Belgium.

***Automotive Technical Congress, Seventh International.**—Mon., 19 May, to Wed., 28 May, in Paris. Organised by the Société des Ingénieurs de l'Automobile, 5 Avenue de Friedland, Paris, 8e.

Business Records, Second Conference on.—Tues., 20 May, at the Connaught Rooms, Great Queen Street, London, W.C.2. Organised by Aslib, 4 Palace Gate, London, W.8. Tel. KNIghtsbridge 0444.

Works and Plant Engineers, Conference.—Tues., 20 May, to Fri., 23 May, at the Strand Hotel, Portstewart, near Portrush, Londonderry. Apply to National Industrial Fuel Efficiency Service (N.I.E.F.S.), 71 Grosvenor Street, London, W.1. Tel. HYDe Park 9706.

Standards in Action, Conference.—Wed., 21 May, at the Connaught Rooms, Great Queen Street, London, W.C.2. Held under auspices of the British Standards Institution. Apply to I.Prod.E./B.S.I. Committee, 2 Park Street, London, W.1. Tel. MAYfair 9000.

***Operational Research Society Conference.**—Wed. and Thurs., 21 and 22 May, at the Old Swan Hotel, Harrogate. Organised by the Operational Research Society, 20 Albert Embankment, London, S.E.11.

Royal Ulster Agricultural Show, 91st.—Wed., 21 May, to Sat., 24 May, at the Society's show grounds, Balmoral, Belfast. Offices: The King's Hall, Balmoral, Belfast.

International Water Supply Association, Fourth Congress.—Sat., 24 May, to Sat., 31 May, at Brussels. Apply to Mr. L. Millis, O.B.E., International Water Supply Association, 34 Park Street, London, W.1. Tel. GROsvenor 1092.

***Air Pollution Control Association 51st Annual Meeting.**—Sun., 25 May, to Thurs., 29 May, at Philadelphia. Offices of the Association: 4400 Fifth Avenue, Pittsburg 13, Pa., U.S.A.

American National Office Machinery Association: 39th Annual Exposition.—Mon., 26 May, to Thurs., 29 May, at the Conrad Hilton Hotel, Chicago. Associaton offices: Willow Grove, Pennsylvania, U.S.A.

Packaging Exposition, 27th National.—Mon., 26 May, to Fri., 30 May, at the New York Coliseum, New York. Organised by Clapp and Poliak, Inc., 341 Madison Avenue, New York 17, U.S.A.

Thermal and Hydraulic Power Stations, Conference.—Tues., 27 May, to Sat., 31 May, at the Palais des Congrès, Liége. Subjects to cover boilers, steam turbines, hydraulic turbines and alternators. Organised by the Association des Ingénieurs Electriciens sortis de l'Institut Electrotechnique Montefiore, 31 Rue Saint-Gilles, Liége, Belgium.

***Aeronautical Sandwich Construction and Bonding, First Annual Conference of International Committee on.**—Tues., 27 May, to Sat., 31 May, in Zürich. Offices of the committee: P.O. Box 43, Stockholm-Vällingby 1, Sweden.

***Spectroscopy of Solids, Conference on.**—Wed. and Thurs., 28 and 29 May, at the Royal Radar Establishment, Malvern. Organised by the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7. Tel. KENsington 0048.

Montreal International Trade Fair.—Fri., 30 May, to Sun., 8 June, in the Show Mart, Montreal. Fair offices: Suites 227-228, 1600 Berri Street, Montreal, Canada.

Large Electric Systems, International Conference on, 17th Session.—Sat., 31 May, to Sun., 8 June, in Paris. Offices of the Conference: 112 Boulevard Hausmann, Paris.

CHEMICAL ENGINEERING

ACHEMA Chemical Engineering Exhibition.—Sat., 31 May, to Sun., 8 June, at Frankfurt. Organised by DECHEMA, 25 Rheingau-Allee, Frankfurt-on-Main, Germany.

Padua International Fair and Packaging Salon.—Sat., 31 May, to Sun., 15 June, at Padua, North Italy. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard Street, London, W.1. Tel. GERrard 4951.

***Special Libraries Association, Annual Convention.**—Tues., 3 June, to Thurs., 5 June, at the Hotel Sherman, Chicago, Ill., U.S.A. A "Brainstorming Demonstration" by the Association's Metals Division will form a part of the programme. Association's offices: 31 East Tenth Street, New York 3, U.S.A.

Gas Turbines Conference.—Wed., 4 June to Fri., 6 June, at the hall of the Faculté Polytechnique, Boulevard Dolez, Mons. Organised by the Faculté Polytechnique de Mons, 9 Rue de Houdain, Mons, Belgium.

Israel Tenth Anniversary Exhibition.—Thurs., 5 June, to Thurs., 21 Aug., at the Binyaney Hacoma, Jerusalem. Organised by the Tenth Anniversary Exhibition Co., P.O.B. 6001, Jerusalem, Israel.

Canadian National Business Show.—Mon., 9 June, to Wed., 11 June, in the Automotive Building, Toronto. Show offices: 745 Mount Pleasant Road, Toronto, Canada.

***Vacuum Techniques, First International Congress on.**—Tues., 10 June, to Fri., 13 June, at Namur, Belgium. Apply to the secretariat, CSN/ERM, 30 Avenue de la Renaissance, Brussels 4.

***Cargo Handling Week, Second International.**—Sat., 14 June, to Tues., 24 June, at Antwerp. Offices: 1a Korte Clarenstraat, Antwerp.

British Electrical Power Convention.—Mon., 16 June, to Fri., 20 June, at Brighton. Theme: "Electricity and World Progress—Britain's Contribution." Organised by the British Electrical Power Convention, Eastcastle Street, London, W.1. (Tel. MUSeum 4040.) An exhibition of electrical apparatus will be held in Brighton during the same period. Organisers: The British Electrical Development Association, 2 Savoy Hill, London, W.C.2. Tel. TEMple Bar 9434.

ELECTRONICS

Electronics and Nuclear Energy, Fifth International Congress and Exhibition.—Mon., 16 June, to Mon., 30 June, at Rome. Organised by the Rassegna Internazionale Electtronica e Nucleare, 14 Via delia Scrofa, Rome. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard Street, London, W.1. Tel. GERrard 4951. (Alteration of dates.)

Civil Engineering Problems Overseas, Conference on.—Week commencing Mon., 23 June, at the Institution of Civil Engineers, Great George Street, London, S.W.1. Open, in certain cases, to non-members. Apply to the secretary of the Institution, at the above address. Tel. WHItehall 4577.

Office Machine Dealers' Association, National Exhibition.—Sun., 29 June, to Wed., 2 July, at the Schroeder Hotel, Milwaukee. Association offices: 1542 Hillhurst Avenue, Los Angeles 27, Cal., U.S.A.

Institution of Naval Architects, Summer Meeting in Paris.—Mon., 30 June, to Fri., 4 July. Organised by the Institution of Naval Architects, 10 Upper Belgrave Street, London, S.W.1. Tel. SLOane 4622.

Royal Show.—Tues., 1 July, to Fri., 4 July, in Bristol. Organised by the Royal Agricultural Society of England, 35 Belgrave Square, London, S.W.1. Tel. BELgravia 5323.

***Rarefied Gas Dynamics and Aerothermodynamics, Symposium on.**—Wed., 2 July, to Sat., 5 July, at Nice. Organised by Dr. F. M. Devienne, Laboratoire Méditerranéen de Recherches Thermodynamiques, 2 Avenue Villebois Mareuil, Nice (A.M.), France.

***Ceramics, Congress of the Internation Academy of.**—Thurs., 3 July, to Wed., 9 July, at Ostend, Belgium. Organised by the American Ceramic Society, 2525 North High Street, Columbus 2, Ohio.

***Low Energy Nuclear Interactions and Nuclear Structure, Conference.**—Mon., 7 July, to Sat., 12 July, in Paris. Organised by the Congrès International de Physique Nucléaire, Institut du Radium, Rue Pierre Curie, Paris.

***Radioactivity Congress.**—Mon., 7 July, to Sat., 12 July, in Paris. Organised by the Union Internationale de Physique Pure et Appliquée (U.I.P.P.A.). Apply to Mr. F. Netter, C.E.N., B.P. No. 2, Gif-sur-Yvette, Seine-et-Oise, France.

Sydney Engineering Exhibition.—Mon., 14 July, to Sat., 19 July, at the Royal Agricultural Showgrounds, Moore Park, Sydney. Apply to the Industrial Public Relations Service of Australia, Box 4962, G.P.O., Sydney.

Victoria State Fair.—Mon., 21 July, to Sat., 2 Aug., at the Exhibition Buildings, Melbourne. Organised by the Industrial Public Relations Service of Australia, 82 W. Toorak Road, South Yarra, Victoria.

Eastern Province Agricultural and Trade Show.—In August, at Morogoro, Tanganyika. Organised by the Arusha Chamber of Commerce and Agriculture, P.O. Box 141, Arusha, Tanganyika.

***British Association Meeting.**—Wed., 27 Aug. to Wed., 3 Sept., in Glasgow. Apply to the secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 4677.

British Radio and Television Exhibition, 25th.—Wed., 27 Aug., to Sat., 6 Sept., at Earl's Court, London, S.W.5. Organised by the Radio Industries Council, 59 Russell Square, London, W.C.1. Tel. MUSeum 6901.

Surabaya International Fair.—Fri., 29 Aug., to Sun, 5 Oct., at Surabaya, Indonesia. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard Street, London, W.1. Tel. GERrard 4951.

Leipzig International Autumn Fair.—Sun., 7 Sept., to Sun., 14 Sept., at Leipzig. *Agent:* Leipzig Fair Agency, 127 Oxford Street, London, W.1. Tel. GERrard 0357.

UNIVERSITY EDUCATION

Place of the University in the Education of Civil Engineers, Conference.—Tues., 9 Sept., to Fri., 12 Sept., at the Queen's University of Belfast. Open to civil engineering delegates from industry and the universities. Apply to the organising secretary, David Keir Building, Stranmillis Road, Belfast.

Chemical Exposition, National.—Tues., 9 Sept., to Fri., 12 Sept., at the International Amphitheater, Chicago. Organised by the Chicago Section, American Chemical Society, 86 East Randolph Street, Chicago, Ill., U.S.A.

Electrochemical Society Inc., Conference.—Sun., 28 Sept., to Thurs., 2 Oct., at Ottawa. Offices of the Society: 216 West 102nd Street, New York 25.

***International Railway Congress Association's 17th Congress.**—Mon., 29 Sept. to Tues., 7 Oct., at Madrid. Organised by the Permanent Commission, 19 Rue du Beau-Site, Brussels, Belgium.

Baghdad Agricultural and Trade Fair.—In October, at Baghdad. Apply to the office of the Mutassarif of Baghdad Liwa, Baghdad, Iraq.

Kenya Royal Show.—Wed., 1 Oct., to Sat., 4 Oct., in Nairobi. Organised by the Royal Agricultural Society of Kenya, P.O. Box 30176, Nairobi, Kenya.

Future of Structural Engineering.—Tues., 7 Oct., to Fri., 10 Oct.. Fiftieth Anniversary conference of the Institution of Structural Engineers, to be held at its headquarters, 11 Upper Belgrave Street, London, S.W.1. Tel. SLOane 7128.

Building Trades Exhibition.—Tues., 14 Oct., to Sat., 25 Oct., in the City Hall, Manchester. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

Engineering Industries Association: 11th London Regional Display.—Tues., 21 Oct. to Thurs., 23 Oct., at the Royal Horticultural Society's New Hall, Greycoat Street, and Old Hall, Vincent Square, London, S.W.1. Offices of the Association: 9 Seymour Street, London, W.1. Tel. WELbeck 2241.

Motor Show, 43rd International.—Wed., 22 Oct., to Sat., 1 Nov., at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

American Association for the Advancement of Science.—Fri., 26 Dec., to Wed., 31 Dec., at Washington, D.C., U.S.A. Offices of the Society: 1515 Massachusetts Avenue N.W., Washington 25, D.C., U.S.A.

International Congress on Combustion Engines.—Second quarter of 1959, in Germany. Theme: "Diesel Engines and Gas Turbines up to 1,500 h.p.: Current Problems Concerning Their Design, Production, Development and Running on Site." Apply to the secretary to the national committee, International Congress on Combustion Engines, 6 Grafton Street, London, W.1. Tel. HYDe Park 5107.

Plastics Exhibition and Convention, International (formerly the **British Plastics Exhibition and Convention**).—Wed., 17 June, to Sat., 27 June, 1959, at Olympia, London, W.14. Organised, with the support of the British Plastics Federation, 47-48 Piccadilly, London, W.1 (Tel. REGent 4681), by *British Plastics*, Dorset House, Stamford Street, London, S.E.1. Tel. WATerloo 3333.

A.S.T.M. Third Pacific Area National Meeting.—Week commencing Sun., 13 Sept., 1959, at the Sheraton Palace Hotel, San Francisco, Calif., U.S.A. Organised by the American Society for Testing Materials, 1916 Race Street, Philadelphia, Pa., U.S.A.

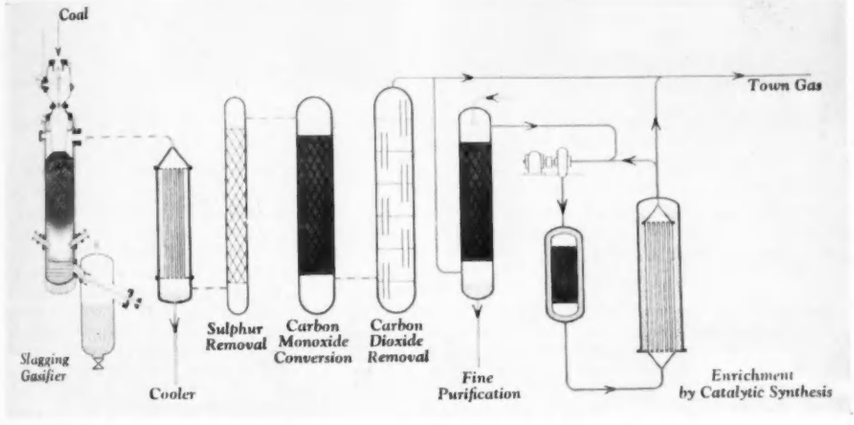
Research and Development

TOWARDS CHEAPER AND BETTER GAS

Research in the gas industry is the responsibility of the Gas Council. The research programme covers many different aspects of gas production and use, but one of its major objects is to develop new processes for cheapening gas manufacture. Changed conditions in the fuel supply position have been taken into consideration, and the work is based on the complete gasification of low-grade coals of high ash content, hitherto considered unsuitable for gas making. It is also planned to gasify coal near to the mines, so reducing transport charges, and to distribute the gas through a national grid system. Greatly extended facilities are now available to the Gas Council, in its research station at Solihull, Warwickshire, which was officially inaugurated recently by Sir Cyril Hinshelwood, F.R.S., President of the Royal Society.

Administered for the Gas Council by the West Midlands Gas Board, the Solihull research station occupies a site of four acres, and consists at present of two main blocks of buildings, with auxiliary plant housed in smaller buildings nearby. Space is available for future extensions. A building 247 ft long and 50 ft wide, in two 25 ft bays, houses an engineering workshop at the rear and chemistry and physics laboratories in the front half; it is planned at a later date to erect a separate building for these laboratories. A two-storey office building extends across the front of the laboratory and workshop block.

Parallel with the workshops and laboratories is a pilot plant block, which is 254 ft long and 42 ft wide. Because of the height of the plant it houses, this building is 51 ft high to the eaves. It has alongside, for most of its length, an 18 ft wide building housing offices for staff working on the pilot plants. On the other side of the main building is an open yard, for equipment suitable for open-air operation, and at the rear is a coal preparation plant.



The slagging gasifier process, shown here diagrammatically, gasifies low-grade coal down to ¼ in in size.

GAS WITHOUT COKE

Gas production by orthodox carbonisation requires a caking coal of low ash content, and since it is this type of coal which is becoming most scarce, research at Solihull is based on complete gasification of coal, the whole of the combustible matter being converted into gas, leaving only the ash to be removed from the vessel. Complete gasification processes are not unknown, but they have only been used in the past on a limited scale and in an auxiliary capacity. Work is therefore proceeding on the development of gasification processes capable of treating any type of coal, including small and dusty coals, on a large scale, at high efficiency. At the same time it is intended that the gas produced shall be of higher quality than ever before; in particular the carbon monoxide content will be low, and sulphur will be absent.

Several possibilities are being examined, but they all share a common feature; the gas is produced at a pressure of several atmospheres. High pressure production has been chosen for a number of reasons. It facilitates rapid gasification of small coal, and enables the high outputs to be obtained from relatively small plants. The yield per ton from gasification is as much as three times that obtained from carbonisation, but the calorific value tends to be lower. This can be corrected by reacting hydrogen with the coal—a pressure reaction. High pressure also simplifies production of high quality gas, enables gas of the same composition to be obtained from different raw materials, and helps to upgrade the by-products. Finally, since distribution of gas under pressure is cheaper, it is an advantage to have it leaving the gasification process already at high pressure.

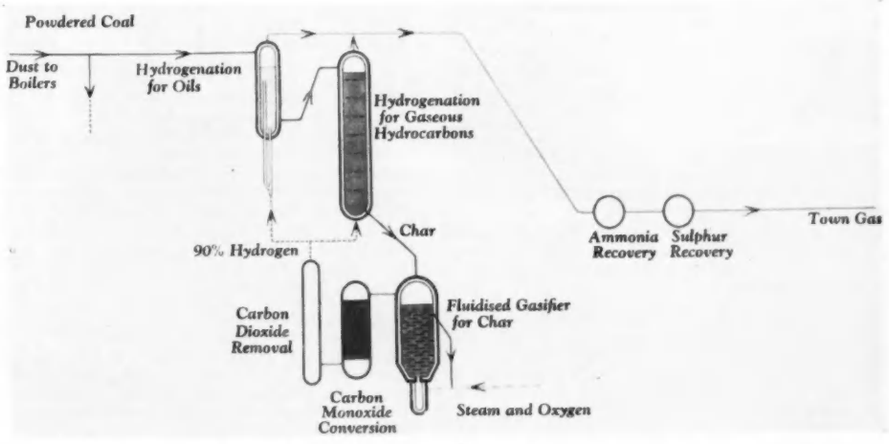
There are three main lines of research in progress on gasification at present. Plant for super-stations is being developed, but this is a fairly long-term project, and other processes are being investigated, with a view to installing high-pressure techniques as soon as possible. The third line of development is on peak-load plant. This equipment has to stand idle for most of the time, and it is therefore desirable that it should be as small, cheap and simple as possible. For this purpose, high-pressure gasification of oil is under investigation. Such plant will have a further use in the short-term provision of high-quality gas in isolated localities, before the gas grid is completed.

RUN-OF-MINE COAL

The Lurgi gasifier, already established in Germany, has been adapted for use with run-of-mine coal over ¼ in in size in this country, and a pilot plant, dealing with coal of up to 30 per cent ash content is in use at Solihull. It gasifies coal completely at a pressure of 20 to 30 atmospheres in a mixture of oxygen and steam, the residual ash being withdrawn by a mechanical grate. Two methods of obtaining gaseous hydrocarbons for enrichment have been developed—by catalytic synthesis from carbon monoxide and hydrogen, and by the hydrogenation of oil. Under present conditions it is cheaper to enrich the Lurgi gas by oil hydrogenation, and this arrangement will be used on a plant to be installed in Scotland and described in our issue of March 28, on page 401.

Somewhat similar to the Lurgi gasifier in its general layout is the slagging gasifier which is under investigation jointly with the Ministry of Power. It operates at a very high temperature, which requires the ash to be withdrawn molten, as a slag. The gasifying vessel is 3 ft in diameter internally and has a water jacket. Fuel is gasified under pressure in a mixture of steam and oxygen, which enters through four tuyeres spaced round the hearth. The ratio of steam and oxygen, which varies from 1·0 to 1·5 by volume, is chosen so that the temperature in the fuel bed fuses the ash, which runs down and collects in the hearth. Periodically, the slag is run from the gasifier to a vessel containing water, which granulates it. A lock hopper releases the granular material from the pressure system.

The gasifier has been operated up till the present with coke as fuel and limestone as flux, and the next step is to adapt the equipment to use various types of British coal. It is necessary for coal fed to the top of the gasifier to be above ¼ in, but there is also a possibility of using a proportion of coal dust, by injecting it with the steam and oxygen through the tuyeres. The gas produced is high in carbon monoxide and of lower calorific value than town gas, and this condition is remedied by converting the carbon monoxide catalytically, partly to hydrogen and partly to methane.



Any size of coal, including dust, can be gasified by the fluidised pressure process.

GAS FROM COAL DUST

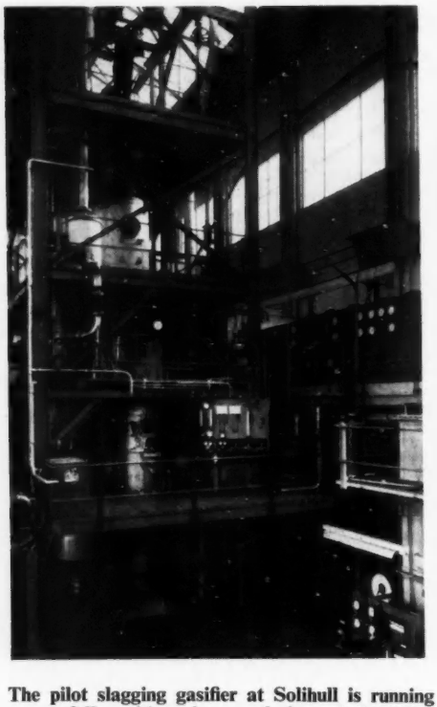
Both the processes previously mentioned require a proportion of the fuel feed to be above ¼ in, but a third process, fluidised coal gasification, will deal with any size of coal down to dust. It incorporates hydrogenation of the coal itself, and will have an overall thermal

Continuing
Research and Development

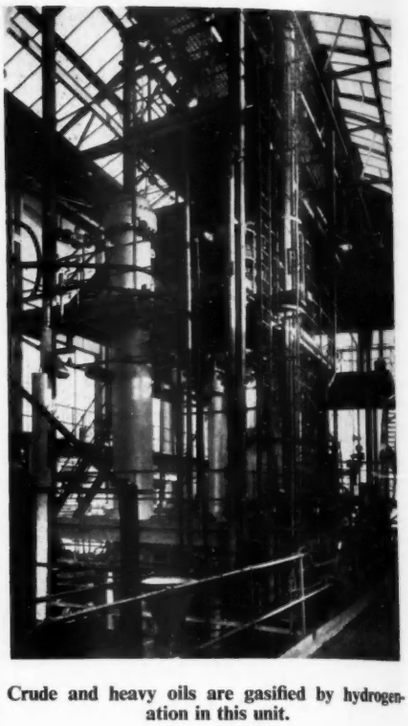
efficiency of 75 per cent. A pilot plant exists, and this process is considered to offer most promise for large-scale operation. Hydrogenation of the coal occurs in a pressure vessel 30 ft high and 1 ft internal diameter, capable of working at pressures up to 50 atmospheres. The coal is crushed to pass a 35 mesh sieve, and is lock-hoppered into the top of the vessel. In a period of about 15 minutes the coal descends the bed, reacting with the hydrogen gas which is passing upwards and keeping the coal in a fluidised state. As with oil the reaction produces gaseous hydrocarbons and by-products, but unlike oil, coal does not hydrogenate to completion and a powder carbon residue remains. Equipment is being constructed to gasify the residue in steam and oxygen, to produce the hydrogen for hydrogenation; meanwhile, hydrogen is obtained by decomposition of part of the gas produced.

Gas manufacture from oil is represented by two processes under development at Solihull. Pressure gasification, based on the Gas Council's process, is capable of operating at a thermal efficiency of 80 per cent. Two versions of this process are available, one for distillate oils which can be vaporised and purified before entering the reaction vessel, and the other for heavy fuel oils and crude oils which must be atomised into the reaction vessel. Oxygen is not required in either case, consequently the plant costs are lower than for coal. A large pilot unit for crude and heavy oils has been erected at Solihull, and a prototype commercial plant is to be installed at Manchester. The distillate oil version is nearer to commercial application, and several Gas Boards have shown an interest in it.

The second process developed for oil gasification is intended for peak-load purposes, and uses light distillate oils. By operating without by-product recovery, plant design is simplified. Thermal efficiency is 85 per cent, and very large outputs are possible; for example, 50 million cu.ft a day are possible from a vessel 10 ft in diameter. On the other hand, economic operation of small units is also possible.



The pilot slagging gasifier at Solihull is running successfully with coke as fuel, and is being adapted to use coal.



Crude and heavy oils are gasified by hydrogenation in this unit.

USE OF GAS

Research into large-scale gas production, while an important part of the work at Solihull, does not occupy the whole of the staff. One laboratory, for example, is devoted to utilisation research, typical current investigations being concerned with high-speed heating, recuperation, and flame traps. Pyrometers and explosion reliefs for industrial ovens are typical examples of developments which have been concluded successfully, and are now in use by Gas Boards and industry generally.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Screwing and Bar Skimming. FRANK WHITELEGG LTD., 304 High Street, Sutton, Surrey. Three illustrated leaflets, the last of a series describing the products of Th. Calow & Co., Bielefeld, Germany. The machines described are: an automatic pipe threader for pipes ⅜ in to 4 in diameter, a bar skimmer for diameters from $\frac{7}{16}$ in to 1 $\frac{5}{16}$ in, and a thread rolling machine for bolts up to 1 in diameter.

Hydraulic Clamping. POWER JACKS LTD., Maylands Avenue, Hemel Hempstead. Clamping by means of a hand-operated hydraulic pump and any required number of hydraulic cylinders. Illustrated catalogue with descriptive chapter, examples of calculations for a typical layout, and outline drawings with tabulated design data detailing the various types of pump and cylinder available.

Tube Parting and Chamfering. FRANK WHITELEGG, LTD., 304 High Street, Sutton, Surrey. Automatic machine made by Th. Calow & Co., Bielefeld, Germany, for parting off tubes up to 55 mm (2$\frac{1}{16}$ in) in lengths from 20 to 130 mm ($\frac{3}{4}$ to 5 in). Inner and outer chamfers are produced during the parting-off operation. Illustrated leaflet.

Wet Cyclone. PRAT-DANIEL (STANMORE) LTD., Whitecroft, Nailsworth, Glos. Bahco portable wet cyclone for dust extraction; on wheels, it can be attached to any plant. Dust is removed as sludge through drain. Three models with capacities of 265, 295 and 330 c.f.m. Leaflet.

Butterfly Valves. FISHER GOVERNOR CO. LTD., Airport Works, Maidstone Road, Rochester, Kent. Butterfly valves made by the Continental Equipment Co. are now available from Fishers. The range includes diameters up to 36 in, and various modes of operation. Leaflet.

Diesel Engines. NATIONAL GAS AND OIL ENGINE CO. LTD., Ashton-under-Lyne. NM range of horizontal and vertical diesel engines for industrial traction or marine use. Normally aspirated or supercharged; from 160 to 600 h.p. Leaflet 1652 A.

Air Separators. STURTEVANT ENGINEERING CO. LTD., Southern House, Cannon Street, London, E.C.4. Mechanical air separators for particle grading. "Standard" and "Whirlwind" types. Booklet 8704 gives details.

Tapping Attachment. W. O. BULLOCK & SONS LTD., 126 Rodbourne Road, Swindon. Self-reversing tapping attachment, specially designed for plastics and non-ferrous metals. Capacity 10 to 4 B.A. or equivalent. Illustrated leaflet.

Electric Hand Tools. LORANT ENGINEERS (LONDON) LTD., 65 High Street, South Norwood, London, S.E.25. Details of the Suhner range of electric hand grinders and drills, which work on 42 V, 400 cycle current. Illustrated leaflet.

Lighting Fittings. VICTOR PRODUCTS (WALLSEND) LTD., G.P.O. Box 10, Wallsend-on-Tyne. Flameproof and weather proof lighting fittings (for tungsten lamps), junction boxes and accessories. Illustrated catalogue L.600.

Straddle Carriers. BRITISH STRADDLE CARRIER CO. LTD., 95 Wigmore Street, London, W.1. Steelmaster and Timberwolf carriers now have power-assisted steering. Leaflet B.S./1A/58 gives details.

Plug and Ring Gauges. GEORGE TAYLOR & SON (ENGINEERS) LTD., Swan Lane, Coventry. Plain and screw plug and ring gauges, to B.S. 1044. Illustrated folder, with inserted price list.

Irrigation Pump. GILBERT GILKES AND GORDON LTD., Kendal. Flood irrigation pumps, D type for mounting on tractor linkage with p.t.o. drive. Capacity 2,000 g.p.m. Leaflet.

Factory Insulation. U.A.M. GROUP ADVISORY SERVICE, Tolpits, Watford, Herts. Thermal insulation of buildings, using asbestos cement materials. Bulletin No. 2.

Dual-Fuel Engines. NATIONAL GAS AND OIL ENGINE CO. LTD., Ashton-under-Lyne. Dual-fuel engines for oil or gas; normally aspirated or pressure charged F4A ranges 200 to 1,372 h.p. (leaflet 1504) and B4A ranges 700 to 2,480 h.p. (leaflet 1503).

NOW MAGNETO-AERODYNAMICS

Dr. W. R. Sears, director of the graduate school of engineering at Cornell University, believes that magneto-aerodynamics may provide the means for the safe return of artificial earth satellites to the ground. Speaking before the National Academy of Sciences, he defined magneto-aerodynamics as a science "concerned with the partial ionisation of air that occurs when objects pass through it at extremely high speeds—notably during the re-entry of rockets and satellites into the earth's atmosphere."

Dr. Sears went on to explain that friction and compression heat the air in front of a fast-moving object to temperatures high enough to ionise the air. According to research at Cornell, this conductivity can be further increased by "seeding" the air near the moving body with a small amount of an easily ionisable substance such as sodium or potassium. "If this technique can be worked out," continued Dr. Sears, "and if magnetic field strengths comparable to those of permanent magnets can be provided in flight, electric currents will be set up by the motion of the air, and significant forces can be applied directly to the air stream." He believes this method may prove useful in slowing down satellites to prevent their overheating as they enter the atmosphere and that controlled accelerations could also be produced by magneto-aerodynamics, to give rockets increased thrust.

Book Reviews

OF WIDER APPLICATION

Fluid Mechanics for Engineers. By P. S. BARNA. *Butterworths Scientific Publications Limited, 4 and 5 Bell Yard, London, W.C.2.* (57*s.* 6*d.*)

Aeronautics is of such importance that the general training of engineers may be expected to include an elementary knowledge of the scientific bases of flight and propulsion. Research into the underlying aerodynamics has progressed so rapidly, however, that the potential applications of the new knowledge throughout engineering as a whole are as yet far from fully appreciated, notwithstanding that an astonishing number and variety of processes and problems are, either directly or incidentally, influenced by the behaviour of fluids. In addition, moreover, to such—often unsuspected—opportunities for making general use of somewhat specialised data, the information now available permits a fresh and more rational treatment of the standard problems in fluid flow encountered by hydraulic engineers.

Mr. Barna has planned his book with skill and good judgment to present the essentials of each of these aspects in such a way as to explain the mathematical and physical theories underlying all fluid mechanics and to exemplify their practical applications so concisely as to cover most of the engineering student's requirements in a single volume. The text is divided into three parts. The earlier chapters of Part I deal, on conventional lines, with fluid statics, the transformation of energy in ideal and real fluids in motion, and the flow and metering of fluids in closed conduits and open channels. At this appropriate stage, the author introduces the principles of dimensional similarity and exemplifies their utility in typical problems of fluid flow and the resistance of submerged and floating bodies. The associated discussions of model experiments and scale effect serve as a useful background for a chapter devoted to boundary layer theory and pressure distribution over bodies immersed in moving fluids, in the course of which resistance data relative to surface roughness and Reynolds number are presented and discussed, and references—regrettably meagre in a book for engineers—are made to the air resistance of structures and moving vehicles. An introduction to the theory of aircraft wings, including some remarks on aspect ratio and induced drag, completes the study of incompressible fluids.

Part II of the book comprises a single chapter on compressible flow, in which the reader is introduced to the thermodynamic effects of gas flow at high speeds and some of the characteristics of shock waves. Under the heading "Rotodynamic Machinery," Part III deals with centrifugal and axial-flow pumps and fans, and hydraulic turbines, attention being given to similarity relationships and to the less complex, approximate theories of design.

The omission of any consideration of reciprocating hydraulic machinery doubtless accords with the author's avowed objective to emphasise the broad representation of fundamentals, leaving some topics for the individual choice of student or teacher. The text is intended to meet the requirements of undergraduates aiming at a degree or diploma in mechanical or civil engineering, which it does reasonably well provided that it is used to supplement a course of instruction in which numerous points not raised, or inadequately explained, in the text can be satisfactorily covered. The bibliographies and worked-out problems accompanying each chapter are so useful as to suggest that answers should also be given to the numerical exercises reproduced from past examination papers. What must certainly be rectified in any future edition is a considerable number of typographical errors not all of which are obvious to an isolated student. These imperfections do not, however, detract seriously from the sterling merits of the book as a whole which deserve recognition, not only by students but also by engineers within a wide range of industry.

UNSTABLE OSCILLATIONS

Dynamic Instability: Automobiles, Aircraft, Suspension Bridges. By Y. ROCARD. *Crosby, Lockwood and Son Limited, 26 Old Brompton Road, London, S.W.7.* (45*s.*)

If the designer of the first Tacoma Bridge could have been enabled to exact a toll on the traffic in published papers on its spectacular and scientifically interesting collapse, his inept design would have already proved to be the most financially rewarding of any civil engineering project yet undertaken. The constructional engineer, unlike the mechanical or the electrical, may learn more from one failure than from a life-time's output of satisfactory and successful works; moreover, the lessons of such a failure can only be revealed and ultimately assimilated after detailed and extensive analyses such as that presented here by Professor Rocard. It may be doubted, however, whether this author has not given too much of his space to Tacoma—95 pages of text and four pages of plates in a book of little over 200 pages, of which the remainder cover a diversity of topics interestingly but not so exhaustively discussed.

For every designer responsible for a suspension bridge there must be a score, or even a hundred, who are concerned with the problem of wheel shimmy, on aircraft, cars, trucks, or other vehicles. Yet this important subject, which has been extensively investigated in recent years, in this country and the United States, is dismissed with two pages of analysis and a reference to an undated ONERA paper (Office Nationale d'Etudes et de Recherches Aéronautiques).

The scientific level of the book is admirably summarised by the author in his foreword: "It is in fact elementary. However, its simplicity has not been forced where the problem increases in complexity . . .; on the other hand, the author has not abstained from mentioning Lagrange's equations or from using the point above a letter to denote the derivative with respect to time or again from writing p for the operator d/dt." This modest appraisal contrasts with the unusual extravagance of the publisher's puff on the dust jacket. The value of such a treatment as this to the research engineer or designer is that it gives the specialist in any one field a view of related problems in other fields without attempting to exhaust any one particular topic, except, of course, Tacoma.

Many of the problems are introduced with almost dramatic touches of local colour, as, for example, the large-deflection theory of carriage suspension. However, when one reads on the longitudinal stability of automobiles that "Every driver will have observed that after reaching or exceeding a certain speed he must work his steering wheel much more often in order to drive straight ahead," one can only conclude that it is high time the professor bought himself a new motor car.

The book is a translation from the French, as could be readily inferred from the use of the term "restituting force" for "restoring force."

On the Shelf

By Frank H. Smith

Aluminium Laboratories Limited, of Banbury, issue a *Research Bulletin*, which looks (and sounds) as though it should be treated as a periodical. But the February number, for instance, has, tucked away in the bottom left-hand corner of the cover, the title: "Tensile Properties at Elevated Temperatures of Some Noral Aluminium Casting Alloys," whereupon it becomes, as far as I am concerned anyway, a book. This treatise, by R. J. Durham and P. D. Skaer, supplements the same company's earlier bulletin (No. 3, March 1955) by the same authors on "Tensile Properties at Elevated Temperatures of Some Wrought Aluminium Alloys." The *Bulletin*, I believe, is gratis.

The Council of Industrial Design issues a photographic and sample catalogue of well-designed goods which they call *Design Review*. As from 1 April the title has been changed to *Design Index*. It is interesting to note, in passing, that the Council abbreviates itself CoID, thus avoiding confusion with the gentlemen who track down other evil designs. Further information regarding the *Design Index* can be obtained from the Design Centre, 28 Haymarket, London, S.W.1. (TRAfalgar 8000).

Hitherto, the *Yearbook* of the British Standards Institution has been a volume possessing a binding which *graced* a bookshelf. The 1958 edition is a drab card-bound volume, which, unlike the stiff binding, does not look as though it will stand up to its year's life. The price is the same, namely, 15*s.*

One gets used to novels bearing titles which seem to have no bearing on the subject-matter of the contents but when that habit spreads to technical books it tends to become confusing. Normalair Limited, of Yeovil, have just published *Into Thin Air*, by Dr. E. W. Still, and it is not until one reads the lengthy sub-title "A study of the requirements of complete and integrated air-conditioning systems in aircraft and the way in which requirements can be met, together with data and descriptions of various systems and of the equipment required" that one realises that Normalair are not taking on a conjurer's or magician's role. A dust-cover, depicting a sputnik over North America, does little to help.

The monthly article that precedes the abstracts in *Applied Mechanics Reviews* for February deals with the comparatively new problems of aerodynamic heating. This is probably why the accompanying bibliography is shorter than usual and consists of only 30 references. It is, nevertheless, a valuable collection for further reading by those whose interest is awakened by the article. *Hydraulic Power Transmission* has been running a long series of articles and, with the March number, "Principles of Hydraulics," reaches Part XXXIV.

The March issue of the *Journal* of The Institution of Production Engineers carries a useful bibliography (p. 206) of 46 references on "Output Pattern in Repetitive Tasks." This is one of those studies of which the titles tend to confuse the careless cataloguer, since fatigue appears to play a big part in repetition—as any schoolboy will tell you.

I do detest inserts. Those little bits of paper that drop out of a journal when you pick it out of the envelope entreating you to go to a conference, buy a handbook, try a correspondence course, install an encyclopaedia, join a book club. Tcha! Nevertheless, I must tell you of one such drop-out from *Aslib Proceedings*. It is from the International Documentation Centre, Box 405, Stockholm-Vällingby, Sweden, and it seems that they are all agog on the fiche card and film business. Their *Micro Library* will keep readers abreast on new production in microform and will also act as a centre for ordering. The journal, moreover, will contain papers on techniques and progress.

XUM

Metals and Materials

CONTINENTAL STEEL PRICES

The man in the street has at last become conscious of the evils of inflation and has begun to give a vague welcome to any fall in the prices of important commodities, particularly if they take place in an industry in which he does not happen to be employed. The corollary—that increased competition makes employers less willing and less able to grant wage increases—is probably less widely recognised as yet, and the fact that increased international competition must make itself felt in home markets now, and will do so increasingly as tariffs begin to come down under the European Common Market, is probably not yet understood.

There is plenty of evidence that one feature of the recession in the United States is the curtailment of capital expenditure by industry, for example, on buildings and machinery; and the same is probably taking place in Britain and in Continental Europe. It is not surprising, therefore, that the steel industry has been one of the first to suffer. For example, the August Thyssen steel combine, one of the biggest in Germany and with a capacity recently increased to about 3 million tons per annum, cut production by 20 per cent in March (although total German output was maintained) and indicated that it was unlikely to be any higher in April. This was taken to mean that it might not even be maintained at that level. The order books of the largest German steel group, Dortmund-Hoerde, are down to about two months' output. Against this background it is not surprising either that a settlement has been reached of the German steel wages dispute or that Continental steel prices have been drastically cut.

The Brussels Steel Cartel cut prices by amounts up to 13 per cent on 4 April, rounds and bars f.o.b. Antwerp for example being reduced from 101 to 93 dol. a ton (compared with 118 dol. in March 1957). International comparisons of steel prices must be made with great care as the subject is a complex one, but it may be said that these international prices are now below the German home market prices, which has not been the case for some years, so that it is a reasonable guess that German home prices may well come down too. In general, United Kingdom prices for open-hearth steel have been lower than German prices, an argument which has been used on a number of occasions in the British steel industry to show that the British engineering and other steel-using industries have been in a favourable position. It should be added that complications are introduced by the widespread use in Germany of basic Bessemer steel, prices for which are, of course, substantially below those for open-hearth steel. A further complication arises from the fact that whereas Continental export prices are in general below the home prices, the reverse has been true for the United Kingdom where most export prices are above home prices. In times of steel shortage it pays Britain to export goods containing steel rather than steel products. With Continental export prices coming down and delivery dates shortening, it seems very doubtful if we shall be able to maintain this situation; and if British steel consumption, like German, shows signs of lagging we may want to sell abroad as much as we can, whatever the form it is in. In this case drastic revision of our price policy is likely to be necessary. Finally, if German home prices come down, it will probably improve the competitive position of German *vis-à-vis* British machinery exports.

Nevertheless, despite all this there will be many who will see advantages in a moderate increase in competition which, so long as widespread curtailment of production does not result, is probably the best guarantee of efficiency the equivalent equipment for pulverised fuel.

INDUSTRIAL TEXTILES

About a third of the entire output of Great Britain's textile industry is used purely for industrial purposes, and, surprisingly enough, cotton is still more widely employed in industry than any other fibre. Thus, in the form of laminated plastics, cotton is utilised for such purposes as aeroplane propellers, heavy machinery bearings and pile-driver "dollies." In this last application, slabs of laminate about 4 in thick are placed between the hammer and the pile.

The uses to which textiles are put in industry, in the public service and in other applications were shown at the third National Industrial Textiles Trade Fair, held in the Royal Albert Hall, London, from 14 to 18 April.

The immense variety of cotton fabrics which are produced in Lancashire for numerous industrial applications was shown on the stand of the Cotton Board. Industrial applications of further natural fibres, including flax, hessian, hemp and jute, were also on view and other sections of the Fair were devoted to displays of man-made fibres produced by Courtaulds Limited, Imperial Chemical Industries Limited (Fibres Division and Leathercloth Division), British Nylon Spinners Limited, and Fibreglass Limited.

The exhibits included fire, acid and flameproof fabrics and protective and industrial clothing of all types; fishing, sports and other nets, and tyres, conveyor belts, fire hose, surgical dressings, electrical-insulating material, filter cloths, elastic fabrics, rot-proof materials, and ropes. These were set out in all their variety on the 80-odd stands of the Fair, which was organised by Trade Fairs and Promotions Limited, Drury House, Russell Street, London, W.C.2.

DIAMOND-BIT PERFORMANCE IN ROCK DRILLS

Drill bits set with large high-grade industrial diamonds are the most economical for use when drilling cores in sandstone rock, but drill bits set with small low-grade diamonds are the most economical in limestone and dolomite. These conclusions have been reached as a result of researches carried out by the United States Bureau of Mines. Two illustrated reports on the subject have been published, namely, R.I. 5384 on "Diamond-Bit Performance in Sandstone," by A. E. Long, and R.I. 5385, on "Diamond-Bit Performance in Limestone and Dolomite," by M. J. Gallagher and A. E. Long. Copies are obtainable on application to the Publications-Distribution Section, U.S. Bureau of Mines, 4,800 Forbes Street, Pittsburgh 13, Pennsylvania, U.S.A. Earlier reports of the Bureau described drilling in gneiss and schist.

FUEL EFFICIENCY IN NON-FERROUS METALLURGY

The non-ferrous metal industry has been changing during the last 20 years, as thermal treatments have become less dependent on the direct burning of solid fuel, and coal and coke have been replaced by gas, oil and electricity. All furnace equipment was once sited on the perimeter of a works to facilitate the handling of solid fuel and the removal of ashes. More often than not, the furnace plant backed on to a canal bank and was open to the elements.

In his opening address at an Institute of Metals conference on "Fuel Efficiency in the Melting and Thermal Treatment of Metals," held in Birmingham on February 26, Mr. F. C. Ashen, of Imperial Chemical Industries Limited, Metals Division, Birmingham, stated that with the exception of special melting shops, furnace equipments were now in the production flow line and solid fuel had been replaced by gas, electricity and liquid fuel from a pipeline.

Melting by electric induction heating had so many metallurgical advantages that it had the copper and the copper-base alloy field nearly all to itself. Electricity was also highly efficient for final heat treatments to close temperature tolerances or where products of combustion could not be allowed to mix with the charge. If, however, electricity were used where wider tolerances of temperature could be allowed and the products of combustion were not detrimental to the charge, it could be suspected as creating a fuel waste.

The thermal conductance away from the working chamber of a furnace had received far more publicity than the thermal conductance into the material charge. The reason, of course, was that there were commercial concerns interested in the sale of insulating materials to prevent heat losses, and the technical data of refractory and insulating materials were widely distributed. If, however, advantage were taken of the maximum heat-absorption rate of materials, consistent with temperature equalisation, heat would be applied at the optimum potential and in these circumstances, when the choice of fuel and the method of application became all important.

Industrial gas now consisted almost entirely of town gas and while producer gas served its purpose on isolated sites, when town gas was unobtainable, generally speaking, producer-gas plants were rapidly becoming a thing of the past in the non-ferrous metal industry. Pulverised-fuel firing for smaller units was also a disappearing firing method. The reason was principally one of convenience. Pulverised fuel could do its work for heavy-duty and high-temperature firing with as good a thermal efficiency as oil, but oil storage, supply lines and burners were much easier to install and to maintain than was in industry, and of avoidance of wage-inflation.

DEVELOPMENT IN ELECTRO-REFINING OF NICKEL

After seven years of continuous study, research scientists and engineers of the International Nickel Company of Canada Limited have developed a new process for the electro-refining of nickel. The new process eliminates high-temperature oxidation and reduction operations with their attendant losses of metals and sulphur and selenium. Instead, nickel sulphide of low copper content from the Bessemer converter or other source can be cast directly into sulphide anodes and electrolysed for the production of high-purity nickel. This contrasts with the usual electro-refining methods in which a metal anode is employed. Another unique feature of the process is that it permits, for the first time in nickel refining, the commercial recovery of the elements sulphur and selenium as valuable by-products, in addition to the cobalt and precious metals recovered hitherto. At present, sulphur is recovered in the form of liquid sulphur dioxide and sulphuric acid, and selenium is recovered in the refining of copper.

The process is in commercial operation at Port Colborne, Ontario. The recovery of high-purity sulphur has been studied jointly with the Blaw-Knox Company with the result that a sulphur fractional distillation unit having a capacity of 100 tons a day has been constructed. The sulphur from this unit contains less than five ppm of selenium and has an unusually low content of ash and bitumen. At Copper Cliff, Ontario, pure selenium is recovered from the residue.

NOTICES OF MEETINGS

British Interplanetary Society

LONDON
Annual General Meeting. Caxton Hall, off Victoria Street, S.W.1. Sat., 3 May, 6 p.m. (Open to members only.)

Building Centre

LONDON
Film: "Rustodian" (Calcium Plumbate Paint), exhibited by Associated Lead Manufacturers Ltd. Wed., 30 April, 12.45 p.m.

Chemical Society

LONDON
Heinrich Wieland Memorial Lecture by Professor Dr. R. Huisgen. Thurs., 8 May, 7.30 p.m.
EXETER
"Stability of Metal Complexes," by Dr. H. M. N. H. Irving. Washington Singer Laboratories, Prince of Wales Road, Exeter. Fri., 9 May, 5 p.m.
ST. ANDREWS
"Recent Developments in the Chemistry of *tert.*-Butylbenzene," by Professor F. Bell. St. Andrews and Dundee Branch. Chemistry Department, St. Salvator's College, St. Andrews. Fri., 2 May, 5.15 p.m.

Combustion Engineering Association

MANCHESTER
"Utilisation of Small Coals," by G. Doxey. North Western Region. Engineers' Club, Albert Square, Manchester. Wed., 30 April, 2.30 p.m.
NEWCASTLE UPON TYNE
"Removal of Dust and Grit from Boiler Plant Effluents," by Dr. C. J. Stairmand. Northern Region. Royal Station Hotel, Newcastle upon Tyne. Wed., 30 April, 11 a.m.*

Helicopter Association of Great Britain

LONDON
"Canadian Research in the Field of Helicopter Icing," by J. R. Stallabras. Royal Aeronautical Society, 4 Hamilton Place, W.1. Fri., 9 May, 6 p.m.

Illuminating Engineering Society

NOTTINGHAM
Annual General Meeting. Nottingham Centre. Offices of the East Midlands Electricity Board, Smithy Row, Nottingham. Thurs., 1 May, 6 p.m.*
SWANSEA
Informal Meeting. Swansea Group. Offices of the South Wales Electricity Board, The Kingsway, Swansea. Mon., 5 May, 6.30 p.m.

Incorporated Plant Engineers

LONDON
"What Management Requires of a Plant Engineer," by W. J. Worsdell. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Tues., 6 May, 7 p.m.*
GLASGOW
"Oil Firing as Applied to Steam Raising Plant," by A. W. Rooney. Glasgow Branch. Scottish Building Centre, 425-427 Sauchiehall Street, Glasgow. Thurs., 8 May, 7.15 p.m.
LEEDS
"The Raising of the Hoenfells," by A. T. Bride. West and East Yorkshire Branch. The University, Leeds. Mon., 28 April, 7.30 p.m.
PETERBOROUGH
"Engineering Problems in the Beet Sugar Industry," by Dipl. Ing. K. Hample. Peterborough Branch. White Lion Hotel, Church Street, Peterborough. Tues., 6 May, 7.30 p.m.
SOUTHAMPTON
"Generation of Power from Atomic Energy," by H. R. M. Hyder. Southern Branch. Polygon Hotel, Southampton. Wed., 7 May, 7.30 p.m.

Institute of Fuel

LONDON
"Improved Sampling Equipment for Solids in Fuel Gases," by P. G. W. Hawksley, S. Badzioch and J. H. Blackett. Institution of Civil Engineers, Great George Street, S.W.1. Wed., 7 May, 5.30 p.m.*

Institute of Marine Engineers

BRISTOL
Films: "Steam," "Seamless Tube Making" and "Foundry Practice." West of England Section. Grand Hotel, Bristol. Mon., 28 April, 7.30 p.m.

Institute of Petroleum

LONDON
"Recent Developments in Refining," by W. J. Newby. Wed., 7 May, 5.30 p.m.*

Institute of Physics

LIVERPOOL
"The Physical Basis of Life," by Professor J. D. Bernal. Liverpool and North Wales Branch. Department of Electrical Engineering, The University, Liverpool. Fri., 2 May, 7 p.m.*
MALVERN
One-day symposium on "Some Applications of Solid State Physics in Computers and Automation." Joint meeting of Midland Branch and Electronics Group. Priory Lodge Hall, Winter Gardens, Malvern. Tues., 29 April, 10.30 a.m.

Institute of Refrigeration

LONDON
"Current Practice in Marine Insulation," by G. Laing. Junior Institution of Engineers, Pepys House, 14 Rochester Row, S.W.1. Thurs., 1 May, 5.30 p.m.*

Institute of Road Transport Engineers

NOTTINGHAM
Annual General Meeting. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., 30 April, 7.30 p.m.
CARDIFF
Discussion on "Welding Techniques in the Construction of Modern Goods and Public-Service Vehicles." South Wales Centre. South Wales Institute of Engineers, Park Place, Cardiff. Fri., 9 May, 7 p.m.
LIVERPOOL
Annual General Meeting. West Region Centre. Liverpool Architectural Society's Rooms, Bluecoat Chambers, School Lane, Liverpool, 1. Thurs., 1 May, 7.30 p.m

Institution of Civil Engineers

LONDON
"The Chania-Sasumua Water Supply for Nairobi," by H. H. Dixon, G. A. Edington and E. P. FitzGerald. Tues., 29 April, 5.30 p.m.*
"Design and Performance of the Sasumua Dam," by Professor K. Terzaghi. Tues., 6 May, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Economic Usage of Broad-Band Transmission Systems," by R. J. Halsey. Radio and Telecommunication Section. Mon., 28 April, 5.30 p.m.*
"Generator Rotor-Angle Measurement and Display," by J. N. Prewett; "Generator Rotor-Angle Measurement by Stroboscopic Means," by E. B. Powell and M. E. Harper; and "System Phase-Angle Measurements," by F. Moran. Joint meeting of the Measurement and Supply Sections. Tues., 29 April, 5.30 p.m.*
"The Design of a 330 kV Transmission System for Rhodesia," by F. C. Winfield, T. W. Wilcox and G. Lyon. Supply Section. Wed., 30 April, 5.30 p.m.*
"Some Case Histories of Business Computers in the United States," by Dr. A. T. Starr. Measurement and Control Section. Tues., 6 May, 5.30 p.m.*
Annual General Meeting. London Graduate and Student Section. Mon., 12 May, 6.30 p.m.*
BELFAST
Annual General Meeting. Northern Ireland Centre. Civil Engineering Department, David Keir Building, Queen's University, Belfast. Tues., 6 May, 6.30 p.m.
BIRMINGHAM
"Electric Control of Stage and Television Lighting," by F. P. Bentham. South Midland Centre. James Watt Memorial Institute, Great Charles Street, Birmingham. Mon., 5 May, 6 p.m.*
EDINBURGH
Annual General Meeting. South East Scotland Subcentre. Carlton Hotel, North Bridge, Edinburgh. Tues., 29 April, 7 p.m.
GLASGOW
Annual General Meeting. South West Scotland Subcentre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Wed., 7 May, 7 p.m.
LEEDS
Annual General Meeting. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall Road, Leeds. Tues., 6 May, 6.30 p.m.
MANCHESTER
Annual General Meeting. "Supply-Voltage and Current Variations Produced by a 60 ton 3 Phase Electric-Arc Furnace," by Dr. B. C. Robinson and A. I. Winder. North Western Section. Engineers' Club, Albert Square, Manchester. Tues., 6 May, 6.15 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
Annual General Meeting. "Heating and Hot-Water Supply and Demand in Flats," by K. W. Dale. Scottish Branch. Scottish Building Centre, 425-427 Sauchiehall Street, Glasgow, C.2. Tues., 29 April, 7 p.m.

Institution of Locomotive Engineers

LONDON
Films: "Introducing Work Study," "Forgemasters in Steel" and "High-Speed Flight: Part I, Approaching the Speed of Sound." Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Thurs., 1 May, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "How Small Can a Motor Car Be." Automobile Division. Tues., 29 April, 6 p.m.*
Discussion on "Means of Increasing Production in Drawing Offices." Industrial Administration and Engineering Production Group. Wed., 30 April, 6 p.m.*
James Clayton Lecture on "Large Pipeline Projects," by A. C. Hartley. Fri., 2 May, 6 p.m.*

Institution of Production Engineers

LONDON
Various short lecturettes. London Graduate Section. Wed., 30 April, 7.15 p.m.
BIRMINGHAM
"Product Design," by R. Cantor. Midlands Region. James Watt Memorial Institute, Great Charles Street, Birmingham. Tues., 13 May, 7 p.m.
MANCHESTER
"Human Problems in Industry," by the Lord Bishop of Manchester. North Western Region. Manchester College of Science and Technology, Sackville Street, Manchester. Mon., 28 April, 6.30 p.m.

Institution of Public Health Engineers

LONDON
Informal Discussion. Caxton Hall, off Victoria Street, S.W.1. Mon., 5 May, 6 p.m.
"Discharge of Sewage and Industrial Wastes into Estuaries," by Dr. B. A. Southgate. Caxton Hall, off Victoria Street, S.W.1. Thurs., 15 May, 6 p.m.

Institution of the Rubber Industry

BIRMINGHAM
Annual General Meeting. Midland Section. James Watt Memorial Institute, Great Charles Street, Birmingham. Wed., 30 April, 6.45 p.m.
GLASGOW
Annual General Meeting. "Rubber in Engineering," with film, by P. B. Lindley. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Tues., 29 April, 7.30 p.m.

Junior Institution of Engineers

BIRMINGHAM
"Protective Relays," by H. S. Lewis. Midland Section. James Watt Memorial Institute, Great Charles Street, Birmingham. Wed., 7 May, 7 p.m.
MANCHESTER
Repetition of Presidential Address on "The Origin and Function of R.E.M.E.," by Major-General W. A. Lord. North Western Section. Engineers' Club, Albert Square, Manchester. Tues., 29 April, 7.30 p.m.

Leeds Metallurgical Society

LEEDS
Annual General Meeting. "Chromising," by Dr. M. L. Becker. Chemistry Wing, The University, Leeds 2. Thurs., 1 May, 7.15 p.m.

Newcomen Society

LONDON
Third Dickinson Biennial Memorial Lecture: "Sixty Glorious Years—The Impact of Engineering on Society in the Reign of Queen Victoria," by Dr. S. B. Hamilton. Wed., 14 May, 5.30 p.m.

North East Metallurgical Society

MIDDLESBROUGH
Annual General Meeting. Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough. Tues., 29 April, 7.15 p.m.

Physical Society

LONDON
"Free Radicals," by Dr. G. J. Minkoff. Low Temperature Group. Royal School of Mines, Prince Consort Road, South Kensington, S.W.7. Thurs., 8 May, 4 p.m.

Royal Aeronautical Society

LONDON
46th Wilbur Wright Memorial Lecture: "Automatic Flight—The British Story," by G. W. H. Gardner. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Thurs., 15 May, 6 p.m.*

Royal Meteorological Society

LONDON
"Progress in Atmospheric Pollution Research," by C. J. Regan; "The Introduction of Smoke Control Areas," by Dr. W. C. Turner; "Climatological Aspects of Air Pollution," by R. G. Veryard; and "Radioactivity in the Atmosphere: Its Origin and Measurement," by N. G. Stewart. Joint Meeting with the National Society for Clean Air. Agricultural House, Knightsbridge, S.W.1. Tues., 13 May, 4.30 p.m.

Royal Society

LONDON
"Seismic Measurements Made by H.M.S. Challenger in the Atlantic, Pacific and Indian Oceans and in the Mediterranean Sea, 1950 to 1953," by T. F. Gaskell, M. N. Hill and J. C. Swallow; and "The Geological Interpretation of Gravity and Magnetic Surveys in Devon and Cornwall," by M. H. P. Bott, A. A. Day and D. Masson-Smith. Thurs., 1 May, 4.30 p.m.*

Royal Society of Arts

LONDON
"Prestressed Concrete," Lecture III, by G. W. Kirkland. Mon., 28 April, 6 p.m.
Discussion on "British Trade and Commerce with the Commonwealth." Wed., 30 April, 2.30 p.m.

Society of Instrument Technology

LONDON
"Data Loggers," by J. L. W. Churchill; "Experience Gained in Using Logging Equipment," by D. H. Whiting; and "Experience Gained in Using Scanning Equipment," by J. Dunkley. Joint Meeting with Data Processing Section. Manson House, Portland Place, W.1. Tues., 29 April, 7 p.m.*
CHESTER
Annual General Meeting and Film Evening. Chester Section. 5 King's Buildings, King Street, Chester. Wed., 30 April, 7 p.m.
MANCHESTER
Annual General Meeting. "Magnetic Amplifiers," by Dr. D. A. Bell. Manchester Section. Manchester College of Technology, Manchester. Tues., 13 May, 7.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Interplanetary Society, 12 Bessborough Gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store Street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke Street, St. James's London, S.W.1. (WHItehall 5536.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire Street, Portland Place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, 61 New Cavendish Street, London, W.1. (LANgham 3583.)
Institute of Physics, 47 Belgrave Square, London, S.W.1. (BELgravia 6111.)
Institute of Refrigeration, New Bridge Street House, New Bridge Street, London, E.C.4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
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Newcomen Society, Science Museum, Exhibition Road, London, S.W.7. (KENsington 1793.)
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Royal Society of Arts, John Adam Street, Adelphi, London W.C.2. (TRAfalgar 2366.)
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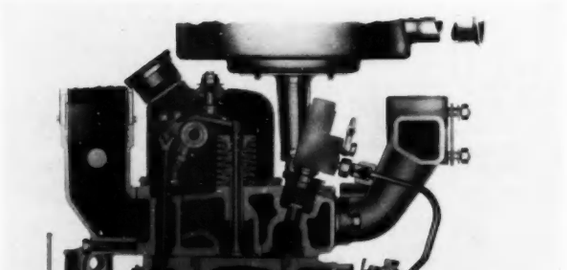
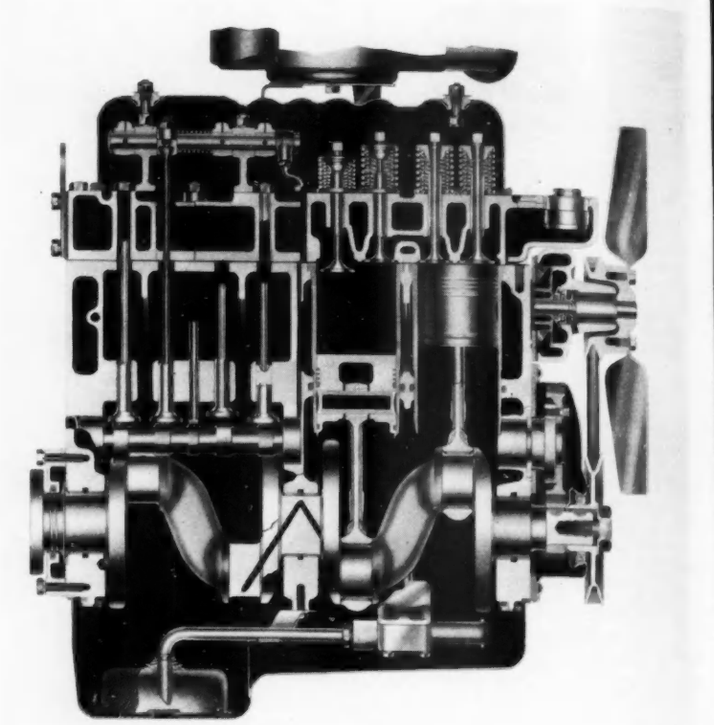
XUM

Design

DIESEL FOR THE PRIVATE CAR





The Perkins "Four-99" embodies a hemispherical combustion chamber.

THE agricultural model of a small diesel engine by F. Perkins Limited, Peterborough, was shown at the last Smithfield Show. Now details have been released and demonstrations given of the vehicle and industrial versions of the same engine. Both models have undergone extensive tests on the road and on the bench; one, fitted in a Bedford C.A. van, ran 101,202 miles on the MIRA testing ground at an average speed of 56 m.p.h. and with an average fuel consumption of 37 m.p.g.

The "Four-99" has a capacity of 1·6 litres from four cylinders; for cars it is rated to give 43 h.p. at 4,000 r.p.m., and for vans and trucks 42 h.p. at 3,600 r.p.m. The industrial version is rated for 32 to 35 h.p. at 3,000 r.p.m.; the basic weight is 320 lb. Bore and stroke are 3 in and 3½ in respectively, and the nominal compression ratio is 20 : 1. The chief design features are the use of a hemispherical combustion chamber and a rotary fuel pump. The combustion chamber is machined in the head, and has its lower half formed by an inserted plug containing the throat. With a flat-topped piston, the squish obtained during the last few degrees of stroke is very large, promoting good combustion. It is also generally claimed that a combustion chamber tends to give a smoother running engine, particularly desirable in a private vehicle.

Cylinder and crankcase are a single iron casting with cast iron wet liners. The cylinder head is also cast iron and carries the valve rocker gear. The inlet valves are chromium steel and the exhaust valves silicon-chromium; both have two springs. The camshaft is of high-duty cast iron, with chilled cams, and is mounted on the offside of the block. The front and the centre bearings are pressure lubricated but the rear bearing relies on splash as also do the cams themselves.

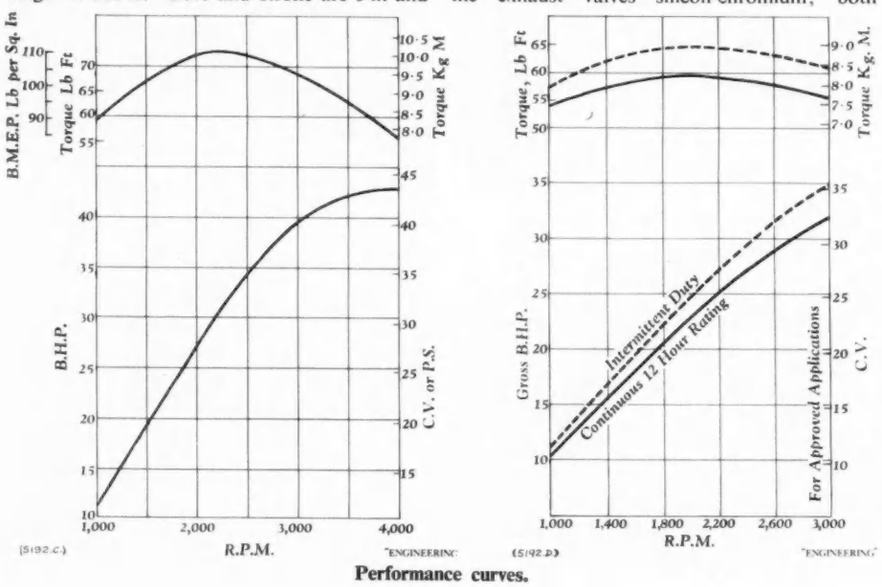
The crankshaft is forged chromium-molybdenum steel and runs in three thin-wall lead-bronze main bearings. The same type of bearing is used for the big-ends and lead-bronze steel backed wrapped small-end bushes are fitted.

The camshaft and fuel pump are driven through gears from the front end of the crankshaft, the gearing being enclosed by a steel cover. Lubrication is by an intermittent feed from the idler hub and by splash and overflow from the main and camshaft bearings.

Forced lubrication is obtained through a Hobourn-Eaton oil pump driven through spiral gears from the camshaft. An adjustable relief valve is fitted in the pump body to control the maximum oil pressure.

The fuel pump is a C.A.V. rotary, type DPA, with provision for automatic timing adjustment to correspond to engine speed. The engine speed itself is controlled by a hydraulic governor on the vehicle engines, and by a mechanical type on the industrial versions. A diaphragm fuel lift pump is fitted on the tappet cover operated by an eccentric on the camshaft and equipped for hand priming. Provision has also been made for fitting a paper element fuel filter if desired.

Conversion sets are available for installing the "Four-99" in the Ford Consul, Vauxhall Velox and Wyvern, the 55/56 Bedford 12 cwt van, the Austin Omnivan and the Morris J2 van. Conversion kits for other vehicles are being prepared. In addition to the above, tests have been carried out in a Morris Oxford, Simca Versailles and Ariane, Mercedes 180D, Austin A70 Utility and Beardmore taxis, mark 7. In the last named, running in London, the fuel consumption has averaged 36 m.p.g. Bore wear observed during tests has been at the rate of 0·001 in per 20,000 miles.



Performance curves.

STIFFENING EFFECTS OF EDGE BEAMS ON A RIGHT SLAB BRIDGE*

By J. A. N. Lee, B.SC.(ENG.)†

EARLY bridges were erected by laying beams across the gap, and paving with small branches placed crosswise, a covering of clay being laid as the wearing surface.

The advent of reinforced and prestressed concrete has meant that the slab has become the basic element of this type of design and not the beam as hitherto, but, as bridge spans have increased and since wheel loads may approach the sides of the deck and cause excessive stresses in the slab, some degree of edge stiffening is frequently necessary; in fact, B.S.153 (Girder Bridges) makes the use of edge beams mandatory in such a case. Moreover, the deck and beams can be cast together and act as a structural whole and a recent survey[1] of Continental bridge designs has shown a tendency towards a construction with two longitudinal beams connected by an integral slab.

The maximum longitudinal bending moment in such a slab, stiffened by two edge beams, is obviously less than in the unstiffened case, but transverse moments may be increased by the addition of the stiffeners, although this latter effect may be offset somewhat if the torsional stiffness of the beams is sufficient to create reversed moments across the span.

Several approaches have been made to the determination of the stresses in such an integral structure under load, various approximations being used to reduce the complexity of the mathematical work.

One idealisation of the problem might be to assume that the slab is simply supported on all four sides, but again it may be shown that although the longitudinal moments in the slab are decreased the transverse stresses are increased. Further, the load on the beams with this assumption will have increased, and in consequence the theoretical bending moment will be in excess of the actual. These factors will have serious effects and will lead to unsafe and uneconomic design of the slab and beams, respectively.

To divide the bridge into some form of grillage would seem a better approximation if it can be assumed that the flexural rigidity of the deck can be simulated by concentrating its strength into lines of beams, transverse and longitudinal. This problem has been solved by Hendry and Jaeger,[2] but though the degree of approximation improves as the number of equivalent beams is increased, the complexity of solution increases rapidly, and it is desirable to have some estimate of the accuracy obtained before a solution is accepted. Fig. 1 compares the "equivalent" grid deflection values with the deflections of a plain slab calculated from the theory which will be given later in this paper. This graph is plotted with the ordinate representing the theoretical deflection values for plate or grid divided by the deflection which would be obtained if the plate were treated as a beam, i.e.,

$$K = \frac{\text{deflection of plate or grid}}{\text{deflection of beam with equal flexural rigidity}}$$

against the aspect ratio of the slab, which is the ratio of the transverse to longitudinal spans, as abscissa.

Methods of analysis whereby it is not necessary to replace the slab by an "equivalent" system have been given by Jensen[3, 4] and Massonet.[5]

The first analysis by Jensen is based on a solution by Nadai[6] for a slab, simply supported on two opposite edges with an infinite transverse dimension, carrying a single-point load. By evolving the necessary boundary conditions for elastic support at a free edge, it is possible to obtain correction terms to Nadai's solution resulting from the additional edge shears and edge moments which must be applied to the infinite slab to reduce the width to a finite dimension. The equations given are for a slab supported on two edge beams which only provide vertical reaction.

The cases quoted vary from a single-point load to uniformly distributed load. These were intended to give the analyses for concrete slabs supported on rolled steel girders and, for this type of structure, it is doubtful whether the effect of torsion has any great effect. A few years later the University of Illinois published experimental verifications of these formulae, the results showing little variation from the theory.

In the same manner of analysis, it is possible to obtain correction factors to the infinite-plate case to allow for the effect of torsion in the edge beams but the resulting equations are extremely complex and do not lend themselves to suitable graphical representation for design use.

Jensen[4] produced a further method of solution applicable to this problem, when he dealt with the analysis of skew slabs. This method, which replaces the governing partial differential equations by finite difference approximations, also neglects torsion. Moreover, since the simultaneous solution of the finite difference equations becomes more difficult as the number of nodes in the domain of the plate is increased, it is tedious to obtain any great degree of accuracy, although these approximations may be used as the basis of a relaxation analysis in which the grid size may be reduced considerably from that used in the finite difference technique.

Following earlier work by Guyon, Massonet extended an analysis of multi-beam bridge decks to the case of a uniform slab and pointed out that, assuming the support given by a stiffening edge beam could be considered to have a sinusoidal distribution along the span, the problem of a slab bridge with edge beams may be solved, provided that the torsional effects of the beams are neglected. This distribution coefficient method of analysis has several other limitations which are inherent in the solutions. Firstly, Poisson's ratio has been neglected and, secondly, the method assumes a continuous sinusoidally distributed applied load. These cause the maximum moments in the slab due to point loads to be underestimated by about 12 per cent and it has been suggested that the theoretical bending moments should be increased by 10 to 15 per cent to compensate for this. In a paper on the application of recent research, Morice[7] gave an indication of a method of approach whereby the load distribution analysis could be extended to include the effect of torsion, but the detailed examination of the problem has not yet been published.

THEORY

The basis of the proposed method lies in the foreknowledge of certain theoretical results independent of the actual problem involved.

From the cross-section of a typical structure, shown in Fig. 2, it may be seen that, if the beams are severed from the slab, interactive shear reactions and moments must be applied to the beams and slab to maintain equilibrium. Consequently, the deflection equations in the slab for applied loading, unknown shear reaction and unknown edge moments together with the corresponding equations for the beam will enable a complete analysis to be obtained by ensuring that the deflections and shapes of the slab boundary and the beam are equal.

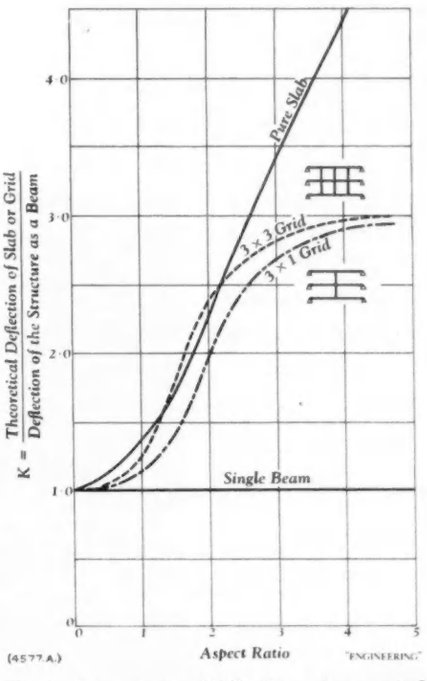


Fig. 1 Comparisons of deflection under a central load on a bridge slab with deflections obtained by analysing the equivalent grillage.

It has been assumed that the interactive reactions may be expressed in the form:

$$\left.\begin{aligned} &\text{shear reaction} && \sum_{m=1}^{\infty} F_m \sin\frac{m\pi x}{2a} \\ &\text{and edge moment} && \sum_{m=1}^{\infty} M_m \sin\frac{m\pi x}{2a} \end{aligned}\right\} \quad . \quad (1)$$

where F_m and M_m are functions dependent on m, $2a$ is the span of the bridge, and x is the co-ordinate from an abutment (see Fig. 3).

From the equations obtained by Nadai for a simply supported plate with infinite transverse width it may be shown that the deflection of a free-edge slab under symmetrical point load, as shown in Fig. 3, is given by:

$$\left.\begin{aligned} &w = w'_0 + w' \quad \text{when} \quad v > y > -v \\ \text{and} \quad &w = w''_0 + w' \quad \text{when} \quad b > y > v \end{aligned}\right\} \quad (2)$$

Where w'_0 and w''_0 are the deflection solutions obtained by Nadai for the "infinite" slab in the appropriate portions and where w' is the correction necessary to satisfy the boundary conditions at $y = \pm b$:

$$\left.\begin{aligned} w'_0 &= \frac{4Pa^2}{\pi^3 D}\sum_{m=1}^{\infty}\frac{1}{m^3}[(1+\alpha v)\cosh\alpha y \\ &\qquad - \alpha y \sinh\alpha y]\, e^{-\alpha v}\sin\alpha u \sin\alpha x \\ w''_0 &= \frac{4Pa^2}{\pi^3 D}\sum_{m=1}^{\infty}\frac{1}{m^3}[(1+\alpha v)\cosh\alpha v \\ &\qquad - \alpha v \sinh\alpha v]\, e^{-\alpha y}\sin\alpha u \sin\alpha x \end{aligned}\right\} \quad (3)$$

where D is the flexural rigidity of the plate and $\alpha = \frac{m\pi}{2a}$.

Then

$$w' = \frac{4Pa^2}{\pi^3 D}\sum_{m=1}^{\infty}\frac{1}{m^3}(A_m \cosh\alpha y - B_m \alpha y \sinh\alpha y)\sin\alpha u \sin\alpha x \quad . \quad (4)$$

when

$$A_m = \left[\frac{4(1+\sigma)+(1-\sigma)^2(1+2\beta^2)+(3+\sigma)(1-\sigma)\cosh 2\beta - \Delta}{\Delta}\right]\cosh\alpha v - \left[\frac{(1-\sigma)^2+(3+\sigma)(1-\sigma)\cosh 2\beta - \Delta}{\Delta}\right]\times \alpha v \sinh\alpha v$$

$$B_m = \left[\frac{(1-\sigma)^2+(3+\sigma)(1-\sigma)\cosh 2\beta - \Delta}{\Delta}\right]\times \cosh\alpha v - \frac{2(1-\sigma)^2}{\Delta}\alpha v \sinh\alpha v$$

in which β (the aspect parameter) $= \frac{m\pi b}{2a}$, σ = Poisson's ratio, and

$$\Delta = (3+\sigma)(1-\sigma)\sinh 2\beta - 2(1-\sigma)^2\beta.$$

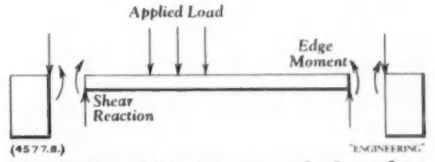


Fig. 2 Interactive moments and shear faces between bridge deck and supporting beams.

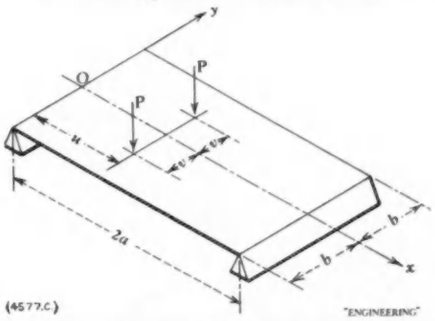


Fig. 3 Application of loads symmetrical about the longitudinal axis.

*Paper read before Section G of the British Association at Dublin, on Monday, September 9, 1957.

†Formerly in the Departments of Civil and Mechanical Engineering, University of Nottingham.

Continuing **Design**

These equations, which are rather complex, have been rearranged, and in general

$$w = \frac{P b^3}{2 a D} \sum_{m=1}^{\infty} \frac{\alpha_y}{\beta^3} \sin \alpha u \sin \alpha x \quad . \quad (5)$$

where α_y is a parameter dependent on the aspect ratio of the slab (transverse span ÷ longitudinal span) and the eccentricity of the loads.

In particular, for a point load at the centre of the plate

$$w = \frac{P b^3}{4 a D} \sum_{m=1}^{\infty} \frac{\gamma_y}{\beta^3} \sin \alpha u \sin \alpha x \quad . \quad (6)$$

where γ_y is the parameter for deflection of the plate at any line distance y from the longitudinal centre-line. The particular values at $y = 0$ and $y = \pm b$ of the respective parameters γ_0 and γ_b are plotted against the aspect parameter for $m = 1$ in Fig. 4. The edge slopes are given as

$$\left.\frac{\partial w}{\partial y}\right]_{y=+b} = \frac{P b^2}{4 a D} \sum_{m=1}^{\infty} \frac{\gamma'_b}{\beta^2} \sin \alpha u \sin \alpha x \quad . \quad (7)$$

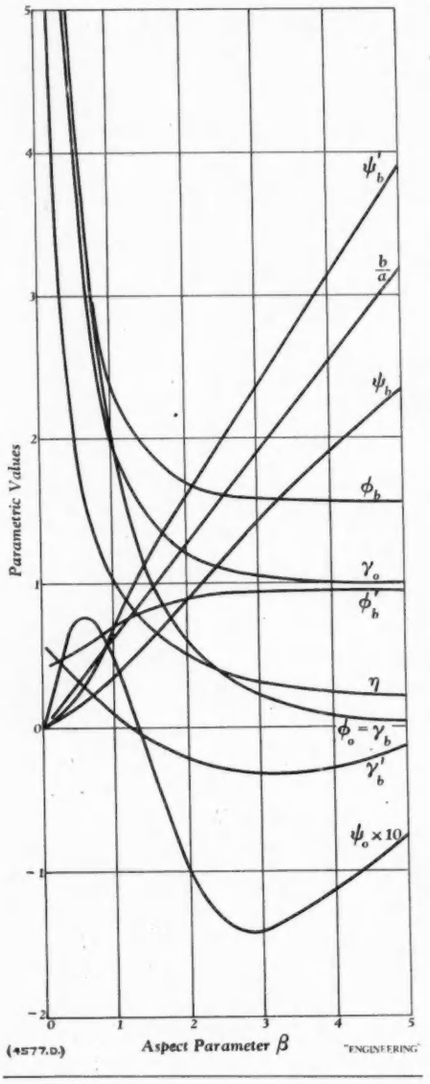


Fig. 4 (left) Graphs of deflection and slope parameters against size of bridge slab for varying types of loading.

The deflection equation for the free-edge slab under the assumed shear reactions, symmetrical on each edge, is given as

$$w = \sum_{m=1}^{\infty} \frac{F_m b^3}{2 D} \frac{\phi_y}{\beta^3} \sin \alpha x \quad . \quad . \quad (8)$$

where

$$\Delta\phi_0 \,(y = 0) = 4\,[2 \cosh \beta + (1 - \sigma)\,\beta \sinh \beta]$$

and

$$\Delta\phi_b \,(y = b) = 8 \cosh^2 \beta.$$

The edge slope is given by

$$\left.\frac{\partial w}{\partial y}\right]_{y=+b} = \sum_{m=1}^{\infty} \frac{F_m b^2}{2 D} \frac{\phi'_b}{\beta^2} \sin \alpha x \quad (9)$$

where

$$\Delta\phi'_b = 4\,[(1 + \sigma) \sinh \beta \cosh \beta - (1 - \sigma)\,\beta].$$

Similarly, solving the bi-harmonic plate equation for the case of the edge moments of the given form

$$w = - \sum_{m=1}^{\infty} \frac{M_m b^2}{D} \frac{\psi_y}{\beta^2} \sin \alpha x \quad . \quad (10)$$

where, at $y = b$,

$$\Delta\phi_b = 2\,\beta\,[(1 + \sigma) \sinh \beta \cosh \beta - (1 - \sigma)\,\beta]$$

and at $y = 0$

$$\Delta\psi_0 = 2\,\beta\,[(1 + \sigma) \sinh \beta - (1 - \sigma)\,\beta \cosh \beta]$$

The edge slope is given by

$$\left.\frac{\partial w}{\partial y}\right]_{y=+b} = - \sum_{m=1}^{\infty} \frac{M_m b}{D} \frac{\psi'_b}{\beta^2} \sin \alpha x \quad (11)$$

where

$$\Delta\psi'_b = 4\,\beta \sinh^2 \beta\,.$$

For the edge beam, it may be shown from first principles (after rearrangement) that the deflection under the assumed shear reaction is given by

$$w = \sum_{m=1}^{\infty} \frac{F_m b^4}{E I} \frac{\eta}{\beta^3} \sin \alpha x \quad . \quad (12)$$

where $\eta = \frac{1}{\beta}$ and E I is the flexural rigidity of the beam and the twist produced by the equal and opposite edge moment is

$$\frac{\partial w}{\partial y} = \sum_{m=1}^{\infty} \frac{M_m b^2}{K G} \frac{\eta'}{\beta^2} \sin \alpha x \quad . \quad (13)$$

where $\eta' = 1{\cdot}0$, and K G is the torsional rigidity of the edge beam.

As previously, these parameters for deflection and slope are plotted for the first term in the series ($m = 1$) in Fig. 4 in which Poisson's ratio has been assumed to be 0·2. In this figure it may be seen that the curves for γ_b and ϕ_0 are coincident, a feature which is consistent with the reciprocal theorem.

As an example in the derivation of the compatability equations, consider the case of a central point load on the slab. At the junction of the slab and beam, the deflections of the two parts must be equal at all points of the longitudinal span and so, for the first term in the series

$$\frac{F_1 b^4}{E I} \eta = \frac{P b^3}{4 a D} \gamma_b \sin \alpha u - \frac{F_1 b^3}{2 D} \phi_b - \frac{M_1 b^2}{D} \psi_b \quad . \quad . \quad . \quad (14)$$

and, for compatability of slopes,

$$\frac{M_1 b^2}{K G} \eta' = \frac{P b^2}{4 a D} \gamma'_b \sin \alpha u - \frac{F_1 b^2}{2 D} \phi'_b - \frac{M_1 b}{D} \psi'_b \quad . \quad . \quad . \quad . \quad . \quad (15)$$

(Kirchoff's conditions show that these two equations of compatibility are sufficient to define the boundary between slab and beam.) From these equations it is possible to evaluate the values of the shear and moment as given by the first term in the series. Having these factors, the values may be substituted into the appropriate deflection (slope or moment) equations and, by summing the effects, the corrected functions may be calculated, for any point in the domain, provided the appropriate parameters are available.

Should the accuracy of the first term be insufficient for the purposes required, further terms must be calculated. The parameter formulae have been so arranged that the integer m has been associated consistently with the aspect ratio in the aspect parameter β. Consequently, to find the parameters relevant to an increased value of m, it is only necessary to increase β by this value and to read off the appropriate factors from the curves of $m = 1$ for the increased value of the aspect parameter. That is to say, for more terms in the deflection, slope or moment parameter series it is merely necessary to consider a bridge m-times as wide and then to obtain the functions as previously.

It must be noted that, as the aspect parameter increases, so the functions αu and αx increase so that the sine terms change. For a point load at the centre of the slab, it may be seen that it is only necessary to take the odd terms of the series, and although the sine function changes sign at each term, its effect is countermanded by a further sine term which is changing in exactly the same manner.

The analysis given so far has been confined to the case of symmetrical loading conditions with respect to the longitudinal axis. To obtain a solution for the asymmetrical or single eccentric load situation, it is necessary to have a further set of parameters referring to the anti-symmetrical case. On superposition of the symmetrical and skew-symmetrical loadings, the required eccentric load state may be obtained. It would be possible with the given equations, together with those for the anti-symmetrical case, to derive equations for single eccentric applied load, and for shear reaction and edge moment on one edge. However, to obtain compatibility for the edge conditions would lead to the simultaneous solution of four equations, and it is far more simple and more accurate to solve two pairs of simultaneous equations, as suggested above, for the symmetrical and anti-symmetrical cases. These four equations would be obtained from equating the deflections along each beam as well as the respective edge slopes, as suggested above for the symmetrical and anti-symmetrical cases.

Commencing from the infinite-plate solutions, expressions can be obtained after superposition of two equations for the case of two loads, distance $2v$ apart, when they act in opposing directions. Then, as previously,

$$w = w'_1 + w'' \quad \text{for} \quad v > y > 0$$
$$w = w''_1 + w'' \quad \text{for} \quad b > y > v$$

when w'_1 and w''_1 refer to the infinite slab and w'' is the correction for finite width,

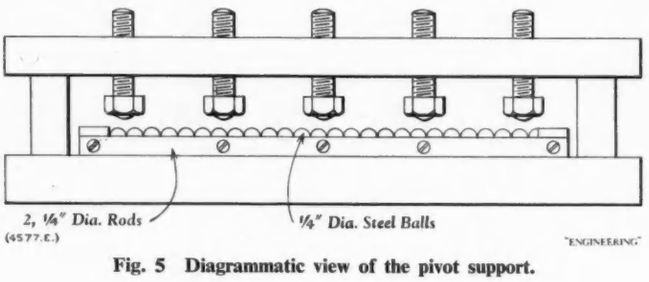


Fig. 5 Diagrammatic view of the pivot support.

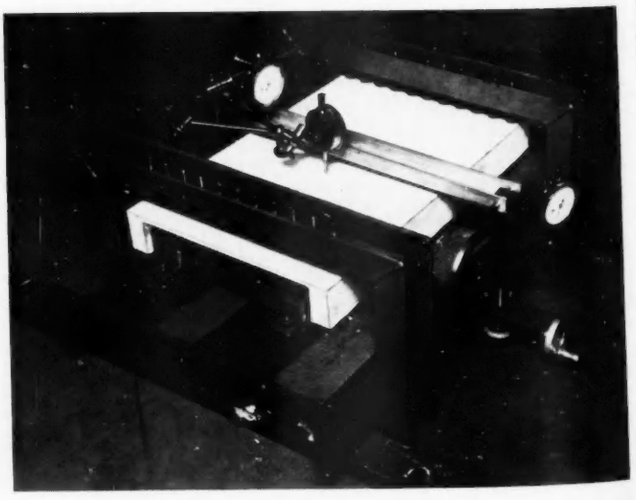


Fig. 6 Apparatus for testing plaster models, showing a typical specimen in position.

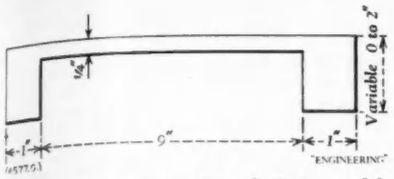


Fig. 7 General cross-section of plaster models.

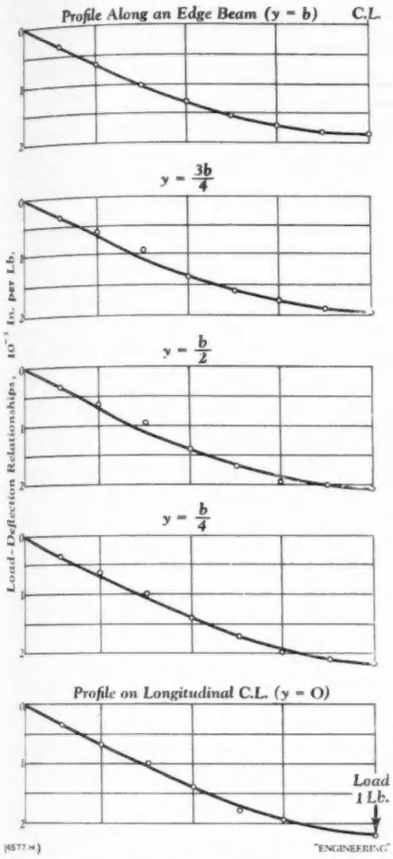


Fig. 8 Comparison of theoretical and experimental load-deflection values from a steel model.

where

$$w'_1 = \frac{4Pa^2}{\pi^3 D}\sum_{m=1}^{\infty}\frac{1}{m^3}[(1+\alpha v)\sinh\alpha y - \alpha y\cosh\alpha y]\,e^{-\alpha v}\sin\alpha u\sin\alpha x$$

$$w''_1 = \frac{4Pa^2}{\pi^3 D}\sum_{m=1}^{\infty}\frac{1}{m^3}[(1+\alpha y)\sinh\alpha v - \alpha v\cosh\alpha v)]\,e^{-\alpha y}\sin\alpha u\sin\alpha x \quad (16)$$

and

$$w'' = \frac{4Pa^2}{\pi^3 D}\sum_{m=1}^{\infty}\frac{1}{m^3}[A_m\sinh\alpha y + B_m\alpha y\cosh\alpha y]\sin\alpha u\sin\alpha x$$

in which

$$A_m = \left[\frac{(3+\sigma)(1-\sigma)\cosh 2\beta - (1-\sigma)^2 - \Delta_1}{\Delta_1}\right]\times \alpha v\cosh\alpha v - \left[\frac{(3+\sigma)(1-\sigma)\cosh 2\beta - 4(1+\sigma) - (1-\sigma)^2(1+2\beta^2) - \Delta_1}{\Delta_1}\right]\times \sinh\alpha v$$

and

$$B_m = \left[\frac{(3+\sigma)(1-\sigma)\cosh 2\beta - (1-\sigma)^2 - \Delta_1}{\Delta_1}\right]\times \sinh\alpha v + \frac{2(1-\sigma)^2}{\Delta_1}\alpha v\cosh\alpha v$$

where

$$\Delta_1 = (3+\sigma)(1-\sigma)\sinh 2\beta + 2(1-\sigma)^2\beta.$$

For anti-symmetrical edge reactions (positive on $y = +b$)

$$w = \sum_{m=1}^{\infty}\frac{F_m b^3}{2D}\frac{\Phi_y}{\beta^3}\sin\alpha x \quad . \quad (17)$$

where

$$\Delta_1\Phi_0 = 0$$

and

$$\Delta_1\Phi_b = 4[\cosh 2\beta - 1]$$

the edge slope is given as

$$\left.\frac{\partial w}{\partial y}\right]_{y=\pm b} = \sum_{m=1}^{\infty}\frac{F_m b^2}{2D}\frac{\Phi'_b}{\beta^3}\sin\alpha x \quad (18)$$

where

$$\Delta_1\Phi'_b = 2[(1+\sigma)\sinh 2\beta + 2(1-\sigma)\beta].$$

For anti-symmetrical moments on the edges (positive on $y = +b$):

$$w = -\sum_{m=1}^{\infty}\frac{M_m b^2}{D}\frac{\Psi_y}{\beta^3}\sin\alpha x \quad . \quad (19)$$

where

$$\Delta_1\Psi_0 = 0$$

$$\Delta_1\Psi'_b = \beta[(1+\sigma)\sinh 2\beta + 2(1-\sigma)\beta]$$

and the edge slope at $y = +b$ is given as

$$\left.\frac{\partial w}{\partial y}\right]_{y=\pm b} = -\sum_{m=1}^{\infty}\frac{M_m b}{D}\frac{\Psi'_b}{\beta^2}\sin\alpha x \quad . \quad (20)$$

in which

$$\Delta_1\Psi''_b = 4\beta\cosh^2\beta.$$

Obviously, the deflection and twist equations for the beams remain the same, and the compatibility equations are of a similar form to those shown for the symmetrical case.

When the bending moments under the load are calculated it will be found that, as a result of the assumed infinitesimal load area, the theoretical moments are infinite. To overcome this failing, it is possible to use the standard moment-stress formulae for finite load areas on an infinite width of slab as given by Westergaard[8] and then to apply the corrective curvatures which may be obtained by differentiating equations (4) and (16) as appropriate.

EXPERIMENTAL VERIFICATIONS

The programme for the investigation of the correlation between the theoretical and experimental load-deflection relationships commenced with the loading of plain slabs without edge beams. These were made from brass sheet approximately 0·1 in thick and were supported in a manner simulating the ideal abutment conditions. At one end, a row of steel balls was placed between two steel rods kept a fixed distance apart so as to provide a pivot support. The other abutment consisted of a similar row of balls on a ground-steel plate to provide a rolling support. At both ends of the span, a set of upper balls was provided, set into the heads of steel bolts which, when screwed towards the plate, would prevent the slab from lifting from the lower bearing on the application of load. The arrangement is shown in Fig. 5. To prevent any twist of the beams which was not counteracted by this arrangement, a pair of balls set into the head of bolts were tightened against the walls of the beams; it was found experimentally that without this attachment in position the maximum deflections could increase by approximately 10 per cent.

Loading was carried out by means of a lever across the slab, having a knife-edge support and bearing into the plate through a $\frac{1}{4}$ in diameter ball. The load was applied to the free end of the lever through a U-shaped device which had the same purpose as a proving ring. Attached to the lower arm of this " U " was a screw which, when tightened against a rigid support, transmitted load to the plate. Vertical deflections were measured by means of dial gauges reading directly to 0·0001 in, mounted as required. In order that deflection readings might be made along the line of the lever arm and at the point of loading, holes were cut in the steel yard to allow the passage of the dial gauge spindle on to the plate or the upper surface of the loading ball. This apparatus is shown in Fig. 6.

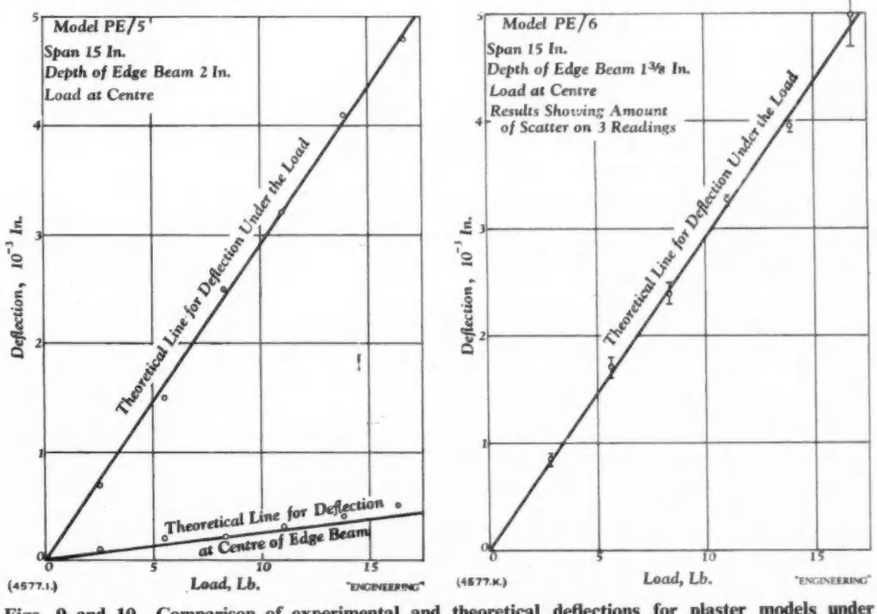
The second step in the research programme was to load a plate with edge beams and the model, about 18 in long by 9 in wide, was cut from a single piece of $\frac{3}{8}$ in black mild-steel plate. The manufacture was difficult and expensive, and other means of making models were considered. One possibility was to use concrete, but doubts were felt as to the suitability of such an inhomogeneous material. Work was then instigated into the suitability and characteristic properties of gypsum plaster. The results[9] of this showed that, with certain precautions, plaster could be used as an elastic material with a low modulus of elasticity (approximately $2{\cdot}0 \times 10^6$ lb per sq. in.) which could be found from a test on a central beam taken from the same mix as the model. It was found that a suitable model size would be about 18 in span, 9 in between beams, $\frac{1}{4}$ in thick slab and edge beams of maximum dimensions of 2 in deep by 1 in wide, as shown in Fig. 7. After stripping the moulds, the specimens were placed in a warm cupboard for a minimum period of 28 days before testing.

RESULTS

Fig. 8 shows a comparison of the theoretical and experimental longitudinal profiles of load-deflection relationships for the steel plate under a central point load. These profiles were obtained by gradually loading the plate and simultaneously measuring the deflection at any point in the domain to obtain load-deflection curves. Having covered the whole plate with a grid of deflection measurements, the experimental results were adjusted by the method of least squares; Fig. 8 compares the theoretical relationships (the solid line) with the adjusted experimental results.

Figs. 9, 10 and 11 show load-deflection results for tests on three plaster models. Fig. 9 shows the theoretical and experimental deflection values under the load and at the centre of an edge beam when the load is applied at the centre of the plate. The beam size for this model is 2 in deep by 1 in wide. The span was 15 in. Fig. 10 shows a similar pair of results for a model of similar span and beam width, but with a beam depth of only $1\frac{3}{8}$ in. Fig. 11 refers to a plaster model similar in cross-section to that of the previous figure but with a single load placed on the centre of one edge beam. The span was 12 in.

In Figs. 9, 10 and 11 the deflection points shown



Figs. 9 and 10 Comparison of experimental and theoretical deflections for plaster models under single central loads.

Production

THE MECHANICS OF MACHINING

Further extracts are given below from six of the papers presented at the Conference on Technology of Engineering Manufacture, arranged by the Institution of Mechanical Engineers, from 25 to 27 March.* The papers are: "Mechanics of the Cutting Process," by Mr. H. Ll. D. Pugh, of the Mechanical Engineering Laboratory, East Kilbride, Glasgow; "A Review of Some Basic Research on the Machining of Metals," by Mr. A. W. J. Chisholm, also of East Kilbride; "Specification of Tool Shape and the Grinding of Cutting Tools," by Mr. D. A. Wight and Mr. J. K. Church, both of PERA, Melton Mowbray; "Developments in Turning and Single-Point Tools, with Particular Reference to Developments in Cutting Tool Materials," by Dr. E. M. Trent, of Hard Metal Tools Limited; "Some Factors Affecting the Performance of Drills and Taps," by Mr. R. J. Cowie and Mr. J. O. M. Pegler, both of PERA; and "Performance Testing of Machine Tools," by Professor H. Opitz, Director of the Laboratory for Machine Tools and Factory Organisation.

Most of the research carried out on machining of metals during the last 50 years has been directed at the reduction of machining costs and the production of components to the required degree of accuracy and surface finish. A much smaller volume of research has been devoted to the fundamental mechanism of machining, but this work is growing in importance with the realisation that it can be of help in the solution of practical problems. The value of such a study is further increased by the fact that although many different types of machining operation are in regular use, they all share the basic wedge-shaped cutting tool and the process of chip removal; any data fundamental to the process will therefore apply to a wide field of machining practice. An understanding of the action of the basic wedge-shaped tool can therefore be the basis for design and development.

Several theories have been formulated on the process, but it has been shown that none of them is in quantitative agreement with experiments, even for a limited range of cutting conditions. That this should be so is not surprising, since none of the theories takes into account the large strain rates, work-hardening and temperatures which exist in the process. Some of these factors, however, produce opposite effects which tend to cancel each other, and the concepts evolved in the attempts to develop the theories have thrown much light on the mechanism of the cutting process. Experiments to check the suggested relation between shear angle, friction angle and rake angle, for example, while not agreeing quantitatively with predictions, have established for each of a number of materials the existence of a linear relation which is unaffected by wide changes in rake angle, cutting speed and lubricants.

* Other extracts appeared on 11 April (p. 478) and 18 April (p. 505).

TOOL SHAPE

Tool wear is influenced by the shape of the tool, and since wear is a major factor governing the rate of production, machining costs and tool consumption costs, this factor deserves full consideration. Unfortunately, owing to the great diversity of operating conditions in practice, it is impracticable to establish by means of tests the most suitable tool shapes for all possible conditions. Consequently, suitable tool shapes for specific operations can only be derived from known suitable shapes for other work. It is also necessary to recognise the basic geometric features, and to understand how they affect the rate of tool wear, and how the optimum values may be influenced by operating conditions. The basic geometric features of tool shape are the normal rake and the effective relief angle.

Normal rake is measured in a plane normal to the cutting edge, and controls the effective rake and the wedge angle, the former being increased and the latter decreased by increasing the normal rake. A high effective rake is needed for minimum cutting energy, but a large wedge angle is necessary for maximum heat conducting capacity and resistance to structural failure. A balance must therefore be struck, and it is determined by that value of normal rake which results in the minimum rate of tool wear. Optimum normal rake may be influenced by a difference in cutting edge inclination or in cutting speed, and the optimum effective relief angle is principally affected by the tool material, the normal rake and the undeformed chip thickness.

TOOL GRINDING

All cutting tools must be reground at intervals to retain their cutting efficiency, and the amount of wear which can be tolerated depends on whether the operation is defined as rough or finish machining. For economic conditions it is necessary to establish a defined stage at which the tool should be reground. Total failure is easy to observe but uneconomic, except when "throw-away" tips are used, and the best criterion is flank wear, because a simple direct measurement gives a good indication of tool condition. A typical wear/time curve shows that wear is constant for the greater part of the time, changing rapidly to a high rate as total failure is approached. It has been calculated that if tool consumption and regrinding costs per component are 1·0 when tools are withdrawn for regrinding at 0·035 in flank wear, the costs at 0·050 in wear will be 1·29, and at total failure they will be 2·36. The choice of 0·035 in wear for regrinding was made because experience has shown that the rate of wear begins to increase between 0·030 in and 0·040 in on carbide tools and between 0·040 in and 0·050 in on high-speed steel tools.

TOOL DEVELOPMENTS

It is obvious that a tool is only of use while it retains the initial geometry chosen for it. To do this it must have high compressive strength, high wear resistance relative to the material being cut, and ability to retain its strength and wear resistance at high temperatures. How these requirements can be met depends upon many factors, but to-day there are numerous tool materials available to suit particular conditions, and new developments are possible. The requirements of industry are changing, and in particular there is a constant demand for increased cutting speeds. As machine tools of greater rigidity and higher speeds are developed, it is likely that the demand for harder and more wear-resistant tool materials will increase, though it is improbable that this will diminish the need for tough materials, suitable for rough surfaces and interrupted cuts. It is possible, though unlikely, that some new hard material will be discovered, and on the whole it is probable that the most urgent demand will be for better tool life at existing speeds.

DRILLS AND TAPS

Drilling is one of the most widely used of all machining operations, and twist drills are often abused through ignorance. Many drills, for example, are still ground by hand, with consequent wide variations in drill life and hole accuracy. Tapping, on the other hand, receives

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Continuing Design

are the average of three sets of readings in each case, the maximum scatter (0·0003 in) being within the accuracy of the dial gauges used. Moreover, it was found that preliminary loading and consequent unloading left a residual deflection in the models and it was found necessary, with a completely fresh model, to apply the load on two or three occasions before taking measurements, to eliminate this effect and to give repetitive readings of deflection.

The method of analysis can be extended to cover other problems of edge stiffening on bridge decks. One obvious extension is to the case of the deep edge beams when the web thickness (assuming some form of I-section) is comparable with that of the slab. With this arrangement the moment constraint of the deck boundary is provided by the "plate bending" of the beam web and not by complete torsional twisting. Hence, if the same shear and moment distributions are assumed at the slab-beam junction, the effect of moment on the upper edge of the web and the resulting deflection from the shear reaction are calculable, and may be equated as previously to the slope and deflection of the slab boundary. With very deep edge beams problems of instability may arise and will require separate investigation.

The stiffening effects of a non-uniform beam cross-section in the span of the bridge are not immediately soluble unless the rate of change of flexural and torsional rigidities can be expressed in a readily integrable form. For practical purposes it would

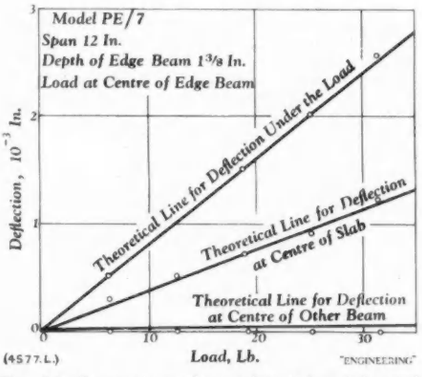

Fig. 11 Comparison of experimental and theoretical deflection values for a plaster model under a single load situated at the centre of one edge beam.

be entirely satisfactory if the effects required for solution could be calculated by a finite difference method using numerical analysis.

Furthermore, an example which shows the power of this method can be found in the case of the simply supported slab deck in a suspension bridge, where a two-pinned stiffening girder may be provided. The combined effects of the tie rods and girder may be represented as continuous load functions.

The author wishes to thank the authorities of the University of Nottingham for the facilities provided in the Engineering Laboratories, and for permission to publish these results.

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Continuing Production

more attention from the production engineer, though here again efficiency can be increased by attention to design.

There is a definite relationship between drill point geometry and drill performance, many factors having an effect besides the well-known one of non-symmetrical point grinding, which is the cause of oversize holes and decreased drill life. Experiments have shown that as the point angle was reduced from 120° to approximately 95°, drill life rose to a maximum. Similarly, tests on relief angle showed that as the nominal relief angle at the outer corner was increased from 4° to approximately 12°, drill life increased; a further increase in relief angle, however, resulted in a reduction of drill life.

Tapping difficulties range from geometric inaccuracies in the threaded holes to tap breakage, and since the latter is often the cause of component scrapping or a lengthy extraction operation, it is essential to reduce the risk of breakage by modifying the tapping conditions to give the least possible torque. The torque increases with the percentage depth of thread, but the strength of a threaded assembly such as a nut and bolt was not increased by providing a depth of thread greater than 60 per cent for steel and aluminium alloy, and 75 per cent for cast iron. The importance of using the largest possible core hole size has been recognised for years, but 75 per cent depth of thread has been the generally accepted minimum. Tests carried out on the torsional and tensile properties of threaded assemblies showed that when using tapped steel nuts it was necessary to reduce the depth or length of tapped holes to below three-quarters of the major thread diameter to ensure failure through thread stripping throughout the range of percentage depth of thread.

MACHINE TOOL TESTING

Cutting tools can only perform satisfactorily if the machines on which they are used are themselves satisfactory. Most constructional specifications are based on Schlesinger limits, but these are mainly concerned with the machines when they are not under load, and they do not enable the overall performance of a machine to be judged. It is possible to obtain some useful information from tests made under static and dynamic load conditions.

Tests are usually started by applying a static load in the direction of the component of the cutting force, which acts in a direction normal to the surface of the workpiece, the load being equal to the actual force expected during operation. After measuring total stiffness, the question of which of the machine elements suffers deformation is considered, and it may be that one part is found to be mainly affected; if so, a weak spot has been discovered, and it can be remedied. Usually, however, all the machine parts subjected to the working load share the deformation of the machine to almost the same amount. If the stiffness of the whole design is to be increased, each of the machine elements will have to be strengthened. Studies of individual elements, such as columns, spindles and bearings have enabled certain basic suggestions for improvements to be made, but more work is needed to determine characteristic behaviour of component parts, and to enable better design data to be formulated.

For dynamic testing comparable considerations are valid, though apparent discrepancies between static and dynamic measurements may occur, and inertia and damping forces have to be taken into account. Effects will vary from one type of machine to another. On a lathe, for example, chatter affects mainly the performance and surface finish; tool life decrease is usually unimportant. On the other hand, torsional vibration in the milling process may cause a decrease in tool life.

SOME NEWER TOOLS AND PROCESSES

Four papers are the basis of further extracts, given below, from the proceedings at the Conference on Technology of Engineering Manufacture to which reference is made in the preceding article. The papers are: " Turning with Ceramic and Sintered Oxide Tools," by Mr. R. C. Brewer, of the Imperial College of Science and Technology; " Developments in Precision Boring," by Mr. C. L. David, of John Lund Limited; " Recent Developments in Broaching," by Mr. F. C. Robinson, of the Lapointe Machine Tool Company, Limited; and " Thread and Form Rolling," by Mr. D. H. Seymour and Mr. F. M. Lomas, both of the Production Engineering Research Association.

NON-METALLIC TOOLS

Non-metals known by the general term " ceramics " are comparative newcomers to machining. They are principally oxides of aluminium, but some attention has been paid to oxides of beryllium, thorium and zirconium. The new materials are of interest particularly because they may be much more readily available than the conventional tools; an economic improvement may be possible with a cheaper tool of comparable performance, or a better performance at comparable price, apart from the general question of tool life; the new material may be more successful as a cutting medium than the older-established ones.

The high speeds at which these new materials will cut may lead to problems; for example many lathes are not equal to such high cutting powers. Given a machine capable of using the tool material to full advantage, good results are possible, and sufficient experiments have now been carried out to enable some reliable conclusions to be stated. For example, it is clear that reasonably high speeds are necessary for all operations; for finishing, the surface roughness increases at the lower speeds, and for roughing, low speeds cause chipping of the cutting edge, and increased machining costs. Friction work increases with cutting speed, thus causing thermal problems, but having, apparently, the redeeming feature of reducing the shear strength of the material. For finishing operations ceramics may be a little superior to carbides for non-ferrous metals and mild steel, comparable for medium strength alloy steels, and inferior for high-carbon and stainless steels. A disadvantage noted is that a built-up edge may be produced in cases where the tool and material being cut contain some common element; this, however, can be controlled, if not eliminated, by the use of a suitable cutting fluid.

BORING

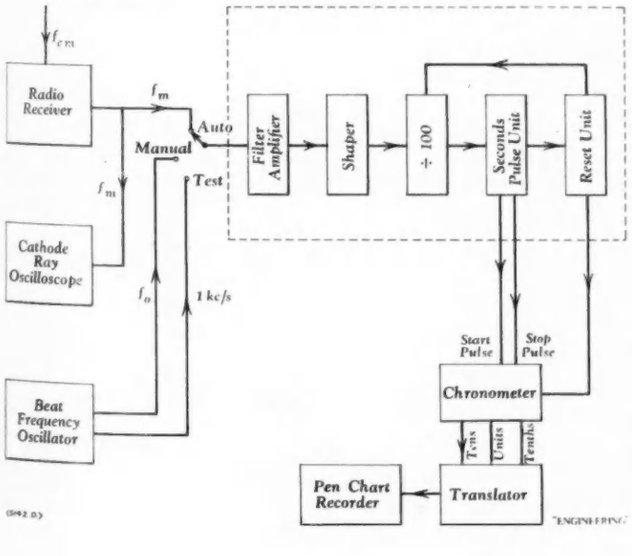
Precision boring for production purposes has developed over the last 25 to 30 years. Whether or not a boring machine will meet requirements depends on three main factors; the workpiece, the cutting tool and the machine and spindle.

Workpiece design may have an important effect on the accuracy of the finished bore, and it is important to remember that lack of roundness can be due to a component which is insufficiently stiff in some part or parts deflecting under the cutting load and then springing back. Similarly, clamping of the component must be so arranged as to avoid distortion. Uneven machining allowances in a bore may cause varying deflection in the boring bar, and this, too, will result in out-of-roundness in the finished job.

Roundness is also dependent upon accurate

Continuing Design

TELEMETERING RADIOSONDE



Automatic radiosonde telemetering equipment was exhibited by Rank Cintel Limited at the recent Physical Society Exhibition The equipment will automatically plot a graph of the temperature, pressure, and humidity variations in the atmosphere as detected and transmitted by a British radiosonde. The method could, say the firm, be adapted to other forms of telemetering and to frequency monitoring.

The radiosonde carries three sensing elements which convert changes in the medium being measured to frequencies in the range 700-1,000 c/s. A wind-driven switch causes these three frequencies to modulate the carrier (27-28 Mc/s) in turn. The repetition rate is about 5 per sec with a 1 sec interval between tones. The complete receiving system used by Rank Cintel is shown in the illustration. The demodulated signal f_m, corresponding at any instant of time to one of the sonde sensing elements, is fed via a filter amplifier having a pass band of 690 to 1,020 c/s to a shaper unit and then to a " divide by 100 " unit, so that one output pulse will be produced for every 100 input pulses. These pulses are passed to a unit that operates a chronometer. Thus of the two pulses that will be contained in 100 cycles of the input the first will produce a start pulse from the unit and the second will produce a stop pulse. The time occupied by the original 100 pulses is thus measured. The last three figures that appear on the chronometer are fed to a translator that changes decade information from the chronometer to a step voltage waveform of 99 steps. This is fed to a pen recorder and thus the graph displays the last three figures of any periodic count. The equipment shown was set to count about 4 to 5 times per signal period. Interposed between each signal group there is usually one random noise count that coincides with the no-signal period. This is followed by another group of counts relating to the next signal, and so on.

Continuing Production

running of the spindle and tool, and correct alignment of spindle and work. Misalignment of these items can result in elliptical or conical bores according to whether the tool or the work is rotating. Many other factors enter into the production of accurate bores, among them the temperature effects from friction of rotating parts and from the machine hydraulic system. Chatter, self-excited by the boring process, lack of balance in rotating parts, and trapping of swarf in the bore are further possible sources of inaccuracy.

BROACHING

Like many other branches of machining, broaching has received a great stimulus from the motor car and aircraft industries, but it also finds a place in many different types of engineering production. The most recent developments in broaching are in the complexity of shapes and contours being cut, and machines are now available which are completely automatic, with speeds of up to 30 ft/min and more. Broaching is now applied to stainless and heat-resisting steels and Nimonic alloys.

In the design of broaching machines the original horizontal type has now returned to supplement the popular vertical models; it is thus possible to operate with strokes which would not be practicable if the machine were vertical. For internal broaching there are vertical machines ranging from 5 to 50 tons capacity, and with strokes up to about 60 in. Vertical machines for surface broaching have capacities from 3 to 25 tons, and strokes usually not more than 90 in. In the horizontal range strokes from 120 to 140 in are now available. Many different types of component feeding equipment can be incorporated in broaching machines, as, for example, automatic hopper feed of components to a moving broach, or continuous chain transport of components past a stationary broach, to give very fast production. On a machine of this type, having 28 travelling fixtures, output can be as high as 1,000 pieces an hour.

THREAD ROLLING

Although the basic technique of thread rolling was developed more than a century ago, its extensive use is much more recent. To-day it is not only practicable to roll screw threads which will be more reliable than those which have been machined, but the process has been extended to the economic production of many other forms such as gear teeth, splines and serrations. The same technique is also being applied increasingly to such operations as burnishing, straightening of shafts and similar components, and forming annular grooves. Threads are now rolled regularly in most steels, and in non-ferrous metals such as aluminium alloys, beryllium, titanium, nickel alloys, copper, brass, bronze, and some die-casting alloys.

Among the many advantages of thread and form rolling are accuracy and uniformity of shape, low labour costs, high-speed production, saving of material, good surface finish and low tool and machine maintenance costs. It is well known that a rolled thread is usually stronger than a cut thread, owing to improvements in the physical properties of the material during the cold working. There are, however, some limitations. Only external threads can be rolled, coarse pitch threads with steep flanks are difficult and it is not possible to roll a square thread. Die life decreases with increasing work hardness, and in general a material hardness of approximately Rockwell C 37 is the economic limit.

Engineering at Home

JIG SAW

The one-hand cutting tool shown on the right is a new addition to the "Lesto" range of electric tools manufactured in Switzerland. It is known as the G.E.B.14. Weighing 5 lb, the device will cut up to $\frac{3}{16}$ in mild steel and up to 2 in wood, Formica, reinforced glass fibre, or similar materials. Various blades of different pitch are available. The gearing design incorporated enables the tool to deliver 2,900 strokes per minute. A power of 200 watts is taken, and the tool is available for voltages between 50 and 250 V, direct or alternating current. Trend Industrial Equipment Limited, Stanmore, Middlesex.

This jig saw will cut up to $\frac{3}{16}$ in thick mild steel.

LIGHT REFLECTOR

The rights to use and market "Alux" in the United Kingdom have been acquired by Veritys Limited, Birmingham. The material is made of aluminium that has been treated to give a high reflectivity. Either reflecting or diffusing surfaces can be produced, to suit the illuminant and the desired light distribution. A hard oxide film coats the surface and the material is sufficiently robust to be washed like glass. In situations where severe corrosion is expected, additional protection can be provided by increasing the oxide film, which can further be protected by a lacquer.

The company claim that the initial reflectivity of the normal material is between 89·7 and 93·5 per cent, reducing to 89 to 92·5 per cent after exposure to industrial atmosphere for one year. By way of comparison, they quote manufactured aluminium as having an initial reflectivity of 75 to 80 per cent, reducing to 35 per cent after one year in similar conditions. The corresponding figures for a silvered mirror are quoted as 89·9 and 86 per cent.

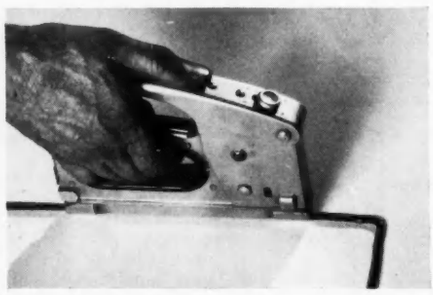
Alux can be produced in most colours; to obtain the best results a half-bowl silvered lamp should be used—then all the light is reflected from the coloured surface. The material is to be used in the production of the standard range of the company's fittings.

JIG BORING MACHINE

At the recent Engineering Industries Association Display, held at Crawley, Sussex, a jig boring machine was displayed by Kine Engineering Company Limited, Redhill, Surrey. It has been designed, say the manufacturers, to meet the increasing demand for an inexpensive but precision machine, for the accurate positioning of holes and for all types of light precision work where versatility and simplicity of operation are required. The machine incorporates the features of a jig boring and vertical milling machine with the advantages contributed by a swivelling head, compound slides and scales, and a rotary table.

The spindle head swivels 30° either way, and is graduated in degrees; the vertical scale is graduated to tenths of an inch and the micrometer dial is graduated in thousandths. The steel spindle is hardened and ground for collet mounting and is equipped with collet and draw rod. The maximum collet capacity is $\frac{3}{8}$ in. A ball thrust bearing is incorporated.

A protected worm and large diameter worm wheel rotates the 8 in table, which is graduated in degrees. The worm spindle is graduated in divisions of two minutes; and the worm housing can be pivoted out of mesh for quick, direct rotation of the table. There are four tee slots with two work clamps. The traverse and longitudinal slides on dovetailed ways have maximum movements of 5 and 7 in respectively. A quarter horsepower motor rotating at 1,425 r.p.m. is used, and 7 speeds are available between 700 and 2,300 r.p.m. Specimens of work produced on the machine to limits of 0·0003 in were shown. The approximate cost of the machine is £260.



The base plate of the tacking gun is shaped so that it can be laid along the length of the cable.

CABLE TACKER

Industrial Staplers Limited have recently introduced a tacking gun that fires a curved-roof staple for fastening wires to surfaces. The size of cable that can be tacked is governed by the staple size—$\frac{7}{32}$ in across the crown and $\frac{3}{8}$ or $\frac{1}{4}$ in down the leg. It is, therefore, serviceable for cables up to $\frac{3}{16}$ in in diameter. The base plate is shaped so that the tool can be laid along the cable and the staples fired into position by depressing the handle. There is a twin-impact selector that enables a "hard" or "soft" strike to be selected, depending on the material that the staples have to be driven into. The gun is about 7 in long and weighs about 2 lb.

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